MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY

Vol. 97 No. 4

---

1937 FEBRUARY 12

## ANNUAL GENERAL MEETING

Mr. J. H. Reynolds, President, in the Chair.

The Minutes of the preceding Annual General Meeting were read and confirmed.

The President announced that His Majesty the King had been pleased to sign the Roll of the Society as Patron.

The President further announced that, by command of the King, the Earl Marshal had invited the Society to send a representative to His Majesty's Coronation in Westminster Abbey on 1937 May 12, and that he (Mr. Reynolds) had been nominated by the Council to represent the Society.

The Report of the Auditors was read, and is given on p. 257.

The Treasurer made a statement in reply to some of the points raised by the Auditors, and showed slides exhibiting the finances of the Society over the previous eighteen years.

A vote of thanks to the Auditors was proposed and carried unanimously.

The Annual Report of the Council was partly read.

The following motion was proposed by the Secretaries and carried unanimously :—

"That bye-law 14 be amended as follows :—

*for* shall be hung up in the meeting-room of the Society,

*read* shall be exhibited in the Library of the Society, or in such other place as the Council may from time to time direct."

[BYE-LAW 14.—"Every recommendation of a proposed Fellow must be delivered to one of the Secretaries, and read at one of the ordinary meetings of the Society ; after which it shall be hung up in the meeting-room of the Society, and there remain until the election is declared."]



UNIVERSITY LIBRARY LEEDS

The Address on the award of the Gold Medal was delivered by the President, after which the Gold Medal was presented to Dr. Harold Jeffreys, to whom it had been awarded for his researches into the physics of the Earth and other planets, and for his contributions to the study of the origin and age of the Solar System.

It was proposed and carried that the Report of the Council be received and adopted, and that it be printed and circulated in the usual manner, together with the Report of the Auditors and the President's Address.

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 385.

Mr. Evershed showed a series of slides illustrating his Observatory. The Astronomer Royal showed a cinematograph film of the pouring of the disc of the 200-inch mirror.

The thanks of the Meeting were given to the retiring members of Council.

The thanks of the Meeting were also given to the Scrutineers of the ballot.

The election by the Council of the following Fellows was duly confirmed:—

M. C. L. Bhalla, M.A., Principal, University Tutorial Academy, 61 Brandreth Road, Lahore, India;

B. C. Browne, M.A., Pembroke College, Cambridge;

Joseph William Henry Crabb, 4 Gordon Place, London, W.C. 1;

Roy Kenneth Marshall, A.B., A.M., Ph.D., Wilson College Observatory, Chambersburg, Pennsylvania, U.S.A.; and

Humphry Montague Smith, High Bryn, 73 Repton Road, Orpington, Kent.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Mark Bernard Brewer Heath, Urania, Firleigh Road, Kingsteignton, Devon (proposed by F. M. Holborn);

Ernest George Martin, Royal Observatory, Greenwich, S.E. 10 (proposed by H. Spencer Jones);

Arnold Smith, M.A., Maltby Grammar School, Rotherham, Yorks (proposed by R. Stoneley); and

Miss Maureen Elizabeth Tindall, 21 Upper Park Road, Hampstead, N.W. 3 (proposed by W. H. Steavenson).

The following election, announced 1936 April 8, is void:—

Mademoiselle Lucy Foltz, Observatoire, Digne, B.A., France.

# REPORT OF THE COUNCIL TO THE HUNDRED AND SEVENTEENTH ANNUAL GENERAL MEETING OF THE SOCIETY.

## PROGRESS AND PRESENT STATE OF THE SOCIETY

| | Patron | Institutional Members | Honorary Member | Fellows | | Associates | Total |
|---|---|---|---|---|---|---|---|
| | | | | Compounders | Annual Subscribers | | |
| 1935 December 31 ... ... | 1 | 4 | 1 | 219 | 676 | 47 | 948 |
| Since elected ... ... ... | ... | ... | ... | ... | +25 | +2 | ... |
| Restored to List ... ... | ... | ... | ... | ... | + 3 | ... | ... |
| Deceased, 1936 ... ... ... | ... | ... | ... | −10 | −15 | −3 | ... |
| Deceased, 1935, not reported till 1936 ... ... | ... | ... | ... | ... | − 1 | ... | ... |
| Resigned ... ... ... ... | ... | ... | ... | ... | −18 | ... | ... |
| Since compounded ... ... | ... | ... | ... | + 1 | − 1 | ... | ... |
| Removed from list ... ... | ... | ... | ... | ... | − 8 | ... | ... |
| 1936 December 31 ... ... | 1 | 4 | 1 | 210 | 661 | 46 | 923 |

(Seven Associates are also Fellows, and are therefore counted twice in the above table.)

*Cash*

RECEIVED

| | £ s. d. | £ s. d. |
|---|---|---|
| Balances, 1936 January 1 :— | | |
| In hand of Assistant Secretary on Petty Cash Account ... ... | 2 7 5 | |
| At Bankers', on Current Account ... ... ... ... ... | 938 1 1 | |
| At Bankers', on "C" Account :— | | |
| Trust Funds ... ... ... ... ... £146 8 2 | | |
| Proceeds of Sales of Duplicate Books ... ... 33 8 0 | | |
| | 179 16 2 | |
| | | 1120 4 8 |
| Received on account of Dividends :— | | |
| £1250 Metropolitan Consolidated 3% Stock ... ... ... ... | 37 10 0 | |
| £2000 Swansea Corporation 3½% Stock ... ... ... ... | 70 0 0 | |
| £2287, 6s. 9d. East Indian Railway 3% Debenture Stock ... ... | 52 10 7 | |
| £5125 London, Midland and Scottish Railway 4% Debenture Stock | 157 11 10 | |
| £750 London, Midland and Scottish Railway 4% Preference Stock | 23 1 3 | |
| £2400 Gas Light and Coke Co. 3% Consolidated Debenture Stock | 55 7 0 | |
| £2000 Commercial Gas Co. 3% Debenture Stock ... ... ... | 45 15 0 | |
| £1035 Agricultural Mortgage Corporation 4% Debenture Stock, 1961–91 ... ... ... ... ... ... ... ... | 35 10 4 | |
| £695, 16s. Conversion Loan 3½% Stock, 1961 ... ... ... | 24 7 0 | |
| £419, 17s. 11d. Conversion Loan 4½% Stock, 1940–44 ... ... | 18 17 10 | |
| £700 Birmingham Corporation 3% Inscribed Stock, 1947 ... ... | 21 0 0 | |
| £496 Consolidated Loan 4% ... ... ... ... ... ... | 19 16 8 | |
| £2000 New Zealand Consolidated 3½% Loan, 1940 ... ... ... | 70 0 0 | |
| £1000 Hull Corporation 4½% Redeemable Stock, 1952–72 ... ... | 45 0 0 | |
| £1300 War Loan 3½% Inscribed Stock ... ... ... ... | 28 0 0 | |
| £500 New South Wales 4% Stock, 1942–62 ... ... ... ... | 15 7 6 | |
| £1000 Central Electricity Board 4½% Stock, 1957–82 ... ... | 34 11 11 | |
| Income Tax refunded, 1935 April–1936 April ... ... ... | 123 2 6 | |
| Interest on Deposit Account ... ... ... ... ... ... | 3 0 6 | |
| | 880 9 11 | |
| Sales of Publications ... ... ... ... ... ... £331 12 5 | | |
| Reprints ... ... ... ... ... ... ... 89 13 5 | | |
| | 421 5 10 | |
| Sales of Photographs .. ... ... ... ... ... ... | 33 3 6 | |
| Sales of Duplicate Books from Library ... ... ... ... ... | 162 9 0 | |
| Miscellaneous Receipts :— | | |
| London Mathematical Society, Expenses of Meetings £31 0 0 | | |
| Assistant Secretary and Clerk, Pension Premiums ... 19 5 0 | | |
| Postages and Telegrams repaid ... ... ... 7 13 9 | | |
| Use of Telephone ... ... ... ... ... 0 7 3 | | |
| Excess on Subscriptions ... ... ... ... 0 1 7 | | |
| Donation to General Fund ... ... ... ... 2 2 0 | | |
| Donation from Harvard University ... ... ... 20 0 0 | | |
| Donation from University of Michigan ... ... 50 0 0 | | |
| | 130 9 7 | |
| | | 1627 17 10 |
| Herbert Spencer Bequest ... ... ... ... ... ... | ... ... | 1241 0 0 |
| Goodridge Bequest ... ... ... ... ... ... ... | ... ... | 50 0 0 |
| Advance payments for Franklin-Adams Charts ... ... ... | ... ... | 342 0 0 |
| Received on account of Subscriptions :— | | |
| 574½ Annual Contributions for 1936 (including 3 Institutional Membership Fees) + 16s. ... ... ... ... ... ... | 1207 5 0 | |
| 19 Annual Contributions for 1937 in advance (including 1 Institutional Membership Fee) ... ... ... ... ... ... | 39 18 0 | |
| 26 Admission Fees (including 1 for 1935) ... ... ... ... | 54 12 0 | |
| 26 First Contributions (including 1 for 1935) ... ... ... | 54 12 0 | |
| Arrears paid off :— | | |
| 10½ for 1934 at 2 guineas ... ... ... ... 22 1 0 | | |
| 1 for 1934 at 29s. ... ... ... ... ... 1 9 0 | | |
| 44½ for 1935 at 2 guineas (including 1 Institutional Membership Fee) ... ... ... 93 9 0 | | |
| 1 for 1935 at 26s. ... ... ... ... ... 1 6 0 | | |
| 1 for 1935 at 11s. ... ... ... ... ... 0 11 0 | | |
| | 118 16 0 | |
| | | 1475 3 0 |
| 1 Composition Fee (reduced) ... ... ... ... ... ... | ... ... | 14 14 0 |
| Trust Fund Dividends :— | | |
| £1212, 13s. 3d. East Indian Railway 3% Debenture Stock... ... | 27 17 2 | |
| £542, 18s. 2d. India 3½% Stock ... ... ... ... ... | 19 0 0 | |
| £965 Agricultural Mortgage Corporation 4½% Debenture Stock, 1961–91 ... ... ... ... ... ... ... ... | 33 2 4 | |
| £1004 Consolidated Loan 4% ... ... ... ... ... ... | 40 3 2 | |
| Donation from General Fund (balance of George Darwin Lecture Fee) | 9 16 10 | |
| Income Tax refunded, 1935 April–1936 April ... ... ... | 17 19 0 | |
| | | 147 18 6 |
| | | £6018 18 0 |

Examined and found correct.
(Signed) L. M. MILNE-THOMSON.
E. A. CHAMBERLAIN.

1937 *January* 5.

## *Account*

### PAID

| | £ s. d. | £ s. d. |
|---|---|---|
| Assistant Secretary: Salary | 270 0 0 | |
| Clerk: Salary | 190 0 0 | |
| Assistant Secretary and Clerk, for work done for London Mathematical Society | 10 0 0 | |
| Pension Premiums for Assistant Secretary and Clerk | 57 15 0 | |
| Porter and Wife: Wages | 160 17 0 | |
| Health and Unemployment Insurance | 7 2 11 | |
| | | 695 14 11 |
| Licence for Porter | 0 15 0 | |
| Fire and Accident Insurance | 14 3 0 | |
| Telephone | 15 17 3 | |
| Telegraphic Address | 2 0 0 | |
| Time Signal (9 months) | 3 17 0 | |
| Water Rate | 12 12 0 | |
| | | 49 4 3 |
| Postage and Packing:— | | |
| *Monthly Notices*, etc. | 144 9 7 | |
| Office Postages | 60 17 1 | |
| | | 205 6 8 |
| Printing, etc.:— | | |
| *Monthly Notices* (Vol. **96**, Nos. 1–9) | 1149 16 11 | |
| *Geophysical Supplement* (Vol. **3**, Nos. 8–9) | 225 14 6 | |
| *Memoirs* (Vol. **65**, Pt. 3) | 78 16 7 | |
| Reprints | 153 18 3 | |
| Miscellaneous | 44 9 5 | |
| Photo-engraving:— | | |
| *Monthly Notices* £48 7 7 | | |
| *Geophysical Supplements* 14 1 0 | | |
| | 62 8 7 | |
| | | 1715 4 3 |
| Reproduction of Photographs for sale | | 39 14 10 |
| Three Gold Medals | 45 15 0 | |
| Adding Machine for Office | 21 15 0 | |
| Stationery and Office Expenses | 24 10 11 | |
| Library Equipment, Binding, Purchase of Books (General Fund) | 41 18 1 | |
| Purchase of Books (Potter Fund) | 1 6 3 | |
| Subscription to International Telegrams Bureau | 4 10 7 | |
| Subscription to Committee on Library Co-operation | 1 1 0 | |
| Authorised Travelling Expenses | 5 9 0 | |
| Heating and Lighting | 99 13 3 | |
| Fittings and Repairs | 26 1 1 | |
| Balance of George Darwin Lecture Fee | 9 16 10 | |
| House Expenses and Laundry | 22 4 0 | |
| Expenses of R.A.S. Meetings and Committees | 18 13 6 | |
| Expenses of Geophysical Meetings | 7 4 6 | |
| Expenses of L.M.S. Meetings | 6 15 0 | |
| Miscellaneous Expenditure | 11 14 7 | |
| Bank Charges and Cheque Books | 2 9 2 | |
| | | 350 17 9 |
| Purchase of Books from Funds raised by Sale of Duplicate Books | | 141 16 6 |
| | | 3197 19 2 |
| Expenditure on Franklin-Adams Charts | ... ... | 212 8 0 |
| Expenditure from Spencer Bequest:— | | |
| Slide Cabinet | 8 11 6 | |
| Carpet, Linoleum, etc. for Council Room | 65 11 0 | |
| Epidiascope | 45 4 0 | |
| Improvement of Heating Apparatus, Ventilation and Redecoration of Meeting Room | 145 0 5 | |
| Periodicals for Library | 12 3 8 | |
| | | 276 10 7 |
| Purchase of £500 War Loan 3½% Inscribed Stock (Spencer Bequest) | ... ... | 531 13 3 |
| Expenditure on Trust Accounts:— | | |
| George Darwin Lecture Fee | 50 0 0 | |
| Turnor and Horrocks Fund (Library) | 14 13 8 | |
| Harry Watson Fund (Library) | 49 0 4 | |
| | | 113 14 0 |
| Balances, 1936 December 31:— | | |
| In hand of Assistant Secretary on Petty Cash Account | 6 18 5 | |
| At Bankers', on Current Account (including Spencer Bequest, £21, 16*s.* 2*d.*) | 611 1 5 | |
| At Bankers', on Deposit:— | | |
| Balance of Spencer Bequest £411 0 0 | | |
| Advance Payments for Franklin-Adams Charts 423 0 0 | | |
| | 834 0 0 | |
| At Bankers', on "C" Account:— | | |
| Trust Funds £180 12 8 | | |
| Proceeds of Sales of Duplicate Books 54 0 6 | | |
| | 234 13 2 | |
| | | 1686 13 0 |
| | | £6018 18 0 |

*Revenue*

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| To General Expenditure as per Cash Account ... ... ... | 3197 | 19 | 2 | | | |
| ,, Reserve for Accounts due but not presented... ... ... | 195 | 0 | 0 | | | |
| | 3392 | 19 | 2 | | | |
| *Less* Reserve for Accounts due 1935 now written back ... | 250 | 0 | 0 | | | |
| | | | | 3142 | 19 | 2 |
| ,, Amount transferred to Composition Fees Reserve Fund in 1936... ... ... ... ... ... ... ... | | | | 14 | 14 | 0 |
| ,, 16 Annual Contributions in Arrear written off ... ... | 33 | 12 | 0 | | | |
| ,, 14 Annual Contributions 1936 written off as per contra ... | 29 | 8 | 0 | | | |
| | | | | 63 | 0 | 0 |
| ,, Due for Reprints, 1933, written off ... ... ... ... | | | | 0 | 19 | 0 |
| ,, Due for Reprints, 1934, written off ... ... ... ... | | | | 0 | 15 | 0 |
| ,, Excess of Income over Expenditure, 1936 ... ... ... | | | | 10 | 18 | 1 |
| | | | | £3233 | 5 | 3 |

Examined and found correct.

(Signed) L. M. MILNE-THOMSON.
E. A. CHAMBERLAIN.

1937 *January* 5.

## *Account*, 1936

| | | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|---|
| By Subscriptions— | | | | | | | |
| 574½ | Annual Contributions 1936, including 3 Institutional Membership Fees ... ... ... ... ... | 1206 | 9 | 0 | | | |
| 1 | Part ditto (on account) ... ... ... ... ... | 0 | 16 | 0 | | | |
| 20 | ditto, 1936, paid 1935 (including 1 Institutional Membership Fee), now matured ... ... ... | 42 | 0 | 0 | | | |
| 69½ | ditto (less 16s.) outstanding ... ... ... ... | 145 | 3 | 0 | | | |
| 14 | Contributions for 1936 due, but unpaid, in respect of Fellows died, resigned, or names removed, and written off per contra ... ... ... ... | 29 | 8 | 0 | | | |
| 679 | | | | | 1423 | 16 | 0 |
| ,, 1 | Subscription 1934–35, not previously brought into account, received in 1936 in respect of a Fellow resigned in 1933 and now restored to list ... ... | | | | 4 | 4 | 0 |
| ,, 25 | First Contributions at 2 guineas ... ... ... | | | | 52 | 10 | 0 |
| ,, 25 | Admission Fees ... ... ... ... ... ... | | | | 52 | 10 | 0 |
| ,, 1 | Admission Fee and First Contribution previously written off and now recovered ... ... ... | | | | 4 | 4 | 0 |
| ,, 1 | Composition Fee (reduced) ... ... ... ... | | | | 14 | 14 | 0 |
| ,, | 6% of Composition Fees Reserve Fund as per Balance Sheet, transferred to Current Revenue ... ... ... ... | | | | 41 | 13 | 10 |
| ,, | Sundry Debtors, 1936 ... ... ... ... ... ... | | | | 15 | 10 | 4 |
| ,, | Dividends, Sales of Publications and Photographs, and Miscellaneous Receipts, as per Cash Account ... ... | 1627 | 17 | 10 | | | |
| *Less* | Payments due 1934 (19*s.* 9*d.* *less* 15*s.* written off) ... ... ... ... | £0 | 4 | 9 | | | |
| | Payments due 1935 ... ... ... | 3 | 8 | 5 | | | |
| | Advance payments for *Monthly Notices*, Vol. 97 ... ... ... ... | 48 | 7 | 3 | | | |
| | Income Tax (General Fund) 1935 April–1936 April, refunded in 1936 ... | 77 | 8 | 3 | | | |
| | | 129 | 8 | 8 | | | |
| | | | | | 1498 | 9 | 2 |
| ,, | Payments for *Monthly Notices*, Vol. 96, received in 1935 and now matured ... ... ... ... ... | | | | 43 | 19 | 9 |
| ,, | Income Tax (General Fund) deducted at source 1936 April–December, not yet refunded ... ... ... ... | | | | 81 | 14 | 2 |
| | | | | | £3233 | 5 | 3 |

## *Balance Sheet*

### LIABILITIES

| | £ s. d. | £ s. d. |
|---|---|---|
| 19 Subscriptions for 1937, paid in 1936 ... ... ... | | 39 18 0 |
| Sundry Creditors for Accounts due but not presented ... | | 195 0 0 |
| Cash Balances (Income) of Trust Funds— | | |
| Turnor and Horrocks Fund ... ... ... ... | 7 2 10 | |
| Harry Watson Fund ... ... ... ... ... | 55 14 9 | |
| Lee and Janson Fund ... ... ... ... ... | 56 14 8 | |
| Hannah Jackson Fund ... ... ... ... ... | 40 18 10 | |
| George Darwin Lectureship Fund ... ... ... | 20 1 7 | |
| | | 180 12 8 |
| Trust Funds (Capital), as per contra ... ... ... ... | | 2964 0 0 |
| Income Tax on Trust Funds, 1936 April–December, not yet refunded, as per contra ... ... ... ... | | 16 15 9 |
| Special Fund (Capital), as per contra ... ... ... ... | | 1460 0 0 |
| Composition Fees Reserve Fund— | | |
| As at 1935 December 31 ... ... ... ... ... | 680 4 4 | |
| Received in 1936 ... ... ... ... ... ... | 14 14 0 | |
| | 694 18 4 | |
| *Less* 6% transferred to current revenue ... ... ... | 41 13 10 | |
| | | 653 4 6 |
| Advance payments for Franklin-Adams Charts ... ... | 423 0 0 | |
| *Less* expenditure on charts, 1936 ... ... ... ... | 212 8 0 | |
| | | 210 12 0 |
| Advance payments for *Monthly Notices*, Vol. 97 ... ... | | 48 7 3 |
| Credit for overpayment on publications, 1932 ... ... | | 0 11 0 |
| General Fund— | | |
| As at 1935 December 31 ... ... ... ... ... | 17,635 13 4 | |
| *Add* Spencer Bequest ... ... £1241 0 0 | | |
| *Less* cash expenditure from Bequest, 1936 ... ... 276 10 7 | | |
| | 964 9 5 | |
| Goodridge Bequest ... ... ... ... ... | 50 0 0 | |
| Excess of Income over Expenditure, 1936... ... | 10 18 1 | |
| | | 18,661 0 10 |
| | | £24,430 2 0 |

Examined and found correct.

(Signed) L. M. MILNE-THOMSON.
E. A. CHAMBERLAIN.

1937 *January* 5.

## 1936 *December* 31

### ASSETS

| | £ s. d. | £ s. d. |
|---|---|---|
| Sundry Debtors for Subscriptions in Arrears— | | |
| 1 for 1934 ... ... ... ... ... ... | 2 2 0 | |
| 16 for 1935 (*less* 11*s.*) ... ... ... ... ... ... | 33 1 0 | |
| 69½ for 1936 (*less* 16*s.*) ... ... ... ... ... | 145 3 0 | |
| | | 180 6 0 |
| Sundry Debtors, 1936— | | |
| Due for Publications ... ... ... ... ... ... | 12 17 0 | |
| Due for Reprints ... ... ... ... ... ... | 1 18 6 | |
| Due for Photographs ... ... ... ... ... ... | 0 1 0 | |
| Due for Postages ... ... ... ... ... ... | 0 13 10 | |
| | | 15 10 4 |
| Investments of General Fund, valued as in 1935 Balance Sheet | | 17,493 9 6 |
| Investment of £500 Spencer Bequest, 1936, valued at cost ... | | 531 13 3 |
| Investments of Special Fund, valued at cost ... ... ... | | 1460 0 0 |
| Investments of Trust Funds, valued as in 1935 Balance Sheet | | 2964 0 0 |
| Income Tax 1936 April–December, deducted at source and not yet refunded— | | |
| General Fund ... ... ... ... ... ... ... | 81 14 2 | |
| Trust Funds ... ... ... ... ... ... ... | 16 15 9 | |
| | | 98 9 11 |
| Sundry Balances— | | |
| In hand of Assistant Secretary on Petty Cash Account ... | 6 18 5 | |
| At Bankers', on Current Account (including Spencer Bequest, £21, 16s. 2d.) ... ... ... ... ... | 611 1 5 | |
| At Bankers', on Deposit— | | |
| Balance of Spencer Bequest ... ... £411 0 0 | | |
| Payments for Franklin-Adams Charts 423 0 0 | | |
| | 834 0 0 | |
| At Bankers', on "C" Account— | | |
| Trust Funds ... ... ... ... 180 12 8 | | |
| Proceeds of Sales of Duplicate Books ... 54 0 6 | | |
| | 234 13 2 | |
| | | 1686 13 0 |
| | | £24,430 2 0 |
| Astronomical and other Manuscripts, Books, Prints, Photographs and Instruments. | | |
| Furniture, etc. | | |
| Stock of Publications and Photographs for sale. | | Not valued. |
| Two Gold Medals. | | |
| Four Bronze (Jackson-Gwilt) Medals. | | |

INVESTMENTS

As at 1936 December 31

*General Fund*

£1250 Metropolitan Consolidated 3-per-cent. Stock, 1941.
£2000 Swansea Corporation 3½-per-cent. Stock.
£2287, 6*s.* 9*d.* East Indian Railway 3-per-cent. New Debenture Stock.*
£5125 London, Midland and Scottish Railway 4-per-cent. Debenture Stock.*
£750 London, Midland and Scottish Railway 4-per-cent. Preference Stock.*
£2400 Gas Light and Coke Co. 3-per-cent. Consolidated Debenture Stock.*
£2000 Commercial Gas Co. 3-per-cent. Debenture Stock.*
£496 Consolidated 4-per-cent. Loan, 1967.
£500 Agricultural Mortgage Corporation, Ltd., 4½-per-cent. Debenture Stock, 1961–91.*
£1000 Hull Corporation 4½-per-cent. Redeemable Stock, 1952–72.
£1000 Central Electricity Board 4½-per-cent. Stock, 1957–82.*
£2000 New Zealand 3½-per-cent. Loan, 1940.
£700 Birmingham Corporation 3-per-cent. Inscribed Stock, 1947.
£1300 War Loan 3½-per-cent. Inscribed Stock.
£500 New South Wales 4-per-cent. Stock, 1942–62.*

*Grove-Hills Special Fund*

£419, 17*s.* 11*d.* Conversion Loan 4½-per-cent., 1940–44.
£695, 16*s.* 0*d.* Conversion Loan 3½-per-cent., 1961.
£535 Agricultural Mortgage Corporation, Ltd., 4½-per-cent. Debenture Stock, 1961–91.*

*Trust Funds*

£1212, 13*s.* 3*d.* East Indian Railway 3-per-cent. New Debenture Stock.*
£542, 18*s.* 2*d.* India 3½-per-cent. Stock.
£1004 Consolidated 4-per-cent. Loan, 1967.
£965 Agricultural Mortgage Corporation, Ltd., 4½-per-cent. Debenture Stock, 1961–91.*

* Taxed at source.

REPORT OF THE AUDITORS FOR THE YEAR 1936

We have examined the Treasurer's account of receipts and expenditure, the Revenue Account and the Balance Sheet for the year 1936, and have certified them to be correct. All the investment holdings have been certified by the Bank of England or by the Westminster Bank.

The small excess, £11, of income over expenditure as shown by the Revenue Account is misleading, for during the year the Society has received the Spencer Bequest, out of which about £100 has been spent on necessary matters which would ordinarily be met from the general funds. The Revenue Account therefore compares unfavourably with recent years. In this connection we observe that the expenditure on printing has increased by one-third. This greatly enhanced expenditure includes an increase of £216 for the *Monthly Notices* and £192 for the *Geophysical Supplements*.

The sum held in reserve in respect of the liability to Fellows who have compounded is £653 as compared with £680 in 1935.

We have inspected the Society's insurance policies, and make the following remarks :—

(1) the Aircraft Policy has lapsed ;
(2) the insurance policies are kept on the premises instead of at the Bank ;
(3) there appears to be no inventory of the Society's property.

The sale of duplicate books has been continued and has realised £162, out of which the Society has bought for £121 the excessively rare *Pars Posterior* of the *Machina Cœlestis* of Hevelius, thus completing the work in the Society's possession.

No further books are reported as missing since the last audit.

A list has been laid on the table containing the names of those Fellows who are still in arrear for the sums due on 1936 January 1, with the amount due against each Fellow's name.

We have inspected the Society's premises. These appear to be in satisfactory condition, but the existing shelf space in the libraries is becoming exhausted and it is suggested that more shelves should be provided.

We have received from the Assistant Secretary all the information and explanations we have required.

(Signed) L. M. Milne-Thomson.
E. A. Chamberlain.

1937 *January* 6.

GIFTS TO THE GENERAL FUNDS AND PROPERTY OF THE SOCIETY

*The John Lee Gift:* In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

*The Lawson Bequest* (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

*The Carrington Bequest* (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2000 Consols.

*The Lambert Bequest* (1877): C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

*The McClean Bequest* (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2000, free of legacy duty.

*The Farrar Bequest* (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty.

*The Parsons Gift* (1922): The Hon. Sir Charles Parsons, K.C.B., F.R.S., gave to the Society £2500 War Stock 1929–47, in memory of his father, the 3rd Earl of Rosse, who made the 6-foot reflector, and who died 1867 October 31.

*The Grove-Hills Bequest* (1922): Colonel E. H. Grove-Hills, C.M.G., F.R.S., bequeathed to the Society, free of legacy duty, his collection of early astronomical and mathematical books up to the year 1700, together with a sum of £250 to cover the expenses incurred by the Society in connection with the books.

*The Lindemann Bequest* (1931): A. F. Lindemann, Esq., bequeathed to the Society the sum of £1000, free of legacy duty.

*The Archdeacon Potter Bequest* (1933): Archdeacon Beresford Potter bequeathed to the Society a 3/88th share of his residuary estate, amounting to £318, 16*s.* 2*d.*

*The Herbert Spencer Bequest* (1936): Mr. Herbert Spencer, who died in 1903, nominated the Royal Astronomical Society as one of twelve Learned Societies to be eventual beneficiaries of his residuary estate. His estate was wound up in 1936, and the Society's share of the residue amounted to £1241. The conditions of acceptance of the legacy were that the sum received should be spent in certain specified ways by the Governing Body within five years of the date of payment, and might not be used in any way for purposes of endowment.

*The Goodridge Bequest* (1936): Captain J. J. L. Goodridge bequeathed to the Society the sum of £50, free of legacy duty.

### THE GROVE-HILLS SPECIAL FUND

In 1923 the Treasurer, Col. Grove-Hills, collected by his private efforts, with the approval of the Council, a Special Fund to meet the immediate financial difficulties of the Society. The total amount received from all sources (including dividends on the investments representing the fund) has been £1913, 1*s.* 11*d.*, of which £1480, 2*s.* 10*d.* has been invested and is now represented by £535 Agricultural Mortgage 4½ per cent., £419, 17*s.* 11*d.* Conversion Loan 4½ per cent. 1940–44, and £695, 16*s.* Conversion Loan 3½ per cent. 1961.

### THE ARCHDEACON POTTER FUND

The late Archdeacon Beresford Potter, who died 1931 May 10, bequeathed to the Society a 3/88th share of his residuary estate. This legacy was received in 1933, and now stands invested in £300 3½ per cent. War Stock, the cash balance of £17, 15*s.* 2*d.* being expended on the library in 1934. The Council resolved to allocate the dividends from this Fund for the purposes of the library.

| | £ | *s.* | *d.* | | £ | *s.* | *d.* |
|---|---|---|---|---|---|---|---|
| 1936 Jan. 1. Balance of Fund ... ... ... | 8 | 18 | 6 | 1936. Purchase of Books ... | 1 | 6 | 3 |
| 1936. Dividends, War Stock 3½ per cent. ... ... | 10 | 10 | 0 | 1936 Dec. 31. Balance of Fund ... ... ... | 18 | 2 | 3 |
| | £19 | 8 | 6 | | £19 | 8 | 6 |

TRUST FUNDS

*The Lee and Janson Fund :* In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334, 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock.

| | £ | *s.* | *d.* | | £ | *s.* | *d.* |
|---|---|---|---|---|---|---|---|
| 1936 Jan. 1. Balance of Fund ... ... ... | 46 | 15 | 11 | 1936 Dec. 31. Balance of Fund ... ... ... | 56 | 14 | 8 |
| 1936. Dividends, East Indian Railway ... | 7 | 13 | 9 | | | | |
| Income Tax, 1935 April–1936 April, refunded ... | 2 | 5 | 0 | | | | |
| | £56 | 14 | 8 | | £56 | 14 | 8 |

*The Turnor Fund and the Horrocks Memorial Fund :* In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464, 18*s.* East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38, 15*s.*, the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrocks : to this the Society added the sum of £55, 15*s.*, and the whole now stands in £103, 6*s.* East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the library.

| | £ | *s.* | *d.* | | £ | *s.* | *d.* |
|---|---|---|---|---|---|---|---|
| 1936 Jan. 1. Balance of Fund ... ... ... | 4 | 18 | 10 | 1936. Purchase of Books ... | 14 | 13 | 8 |
| 1936. Dividends, East Indian Railway ... | 13 | 1 | 0 | 1936 Dec. 31. Balance of Fund ... ... ... | 7 | 2 | 10 |
| Income Tax, 1935 April–1936 April, refunded ... | 3 | 16 | 8 | | | | |
| | £21 | 16 | 6 | | £21 | 16 | 6 |

*The Harry Watson Memorial Fund :* In 1920 Mrs. Watson presented to the Society the sum of £300 as a memorial to her late husband, Lieut.-Col. Harry James Watson, F.R.A.S., the interest on this sum to be used for the purchase of books for the library, such books to be indicated by a special book-plate. This gift now stands invested in £542, 18*s.* 2*d.* India 3½-per-cent. stock. In 1923 Mrs. Watson bequeathed a further sum of £958, 17*s.* to the Society, which now stands invested in £965 Agricultural Mortgage 4½-per-cent. Stock. The Council resolved

that these two sums should together constitute a Trust Fund, to be designated *The Harry Watson Memorial Fund*, to be used for the purchase and binding of books.

| | £ | s. | d. | | £ | s. | d. |
|---|---|---|---|---|---|---|---|
| 1936 Jan. 1. Balance of Fund ... ... ... | 42 | 17 | 5 | 1936. Purchase of Books ... | 38 | 16 | 1 |
| 1936. Dividends, India 3½ per cent. ... ... | 19 | 0 | 0 | Binding ... ... | 10 | 4 | 3 |
| Dividends, Agricultural Mortgage 4½ per cent. | 33 | 2 | 4 | 1936 Dec. 31. Balance of Fund ... ... ... | 55 | 14 | 9 |
| Income Tax, 1935 April–1936 April, refunded | 9 | 15 | 4 | | | | |
| | £104 | 15 | 1 | | £104 | 15 | 1 |

*The Hannah Jackson (née Gwilt) Fund :* In 1861 Mrs. Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £309, 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock ; the interest to be given in medals or other awards in accordance with the terms of the Trust.

| | £ | s. | d. | | £ | s. | d. |
|---|---|---|---|---|---|---|---|
| 1936 Jan. 1. Balance of Fund ... ... ... | 31 | 14 | 5 | 1936 Dec. 31. Balance of Fund ... ... ... | 40 | 18 | 10 |
| 1936. Dividends, East Indian Railway ... | 7 | 2 | 5 | | | | |
| Income Tax 1935 April–1936 April, refunded ... | 2 | 2 | 0 | | | | |
| | £40 | 18 | 10 | | £40 | 18 | 10 |

*The George Darwin Lectureship Fund :* In 1926 June Sir James Jeans presented to the Society the sum of £1000 for the endowment of an annual lectureship, to be called *The George Darwin Lectureship*, the lecture to be on some subject of interest to astronomers, preference being given, in electing a lecturer, to one normally resident outside the British Isles.

This sum now stands in £1004 Consolidated 4-per-cent. Loan. The income is annually applied to the purposes of the Trust in accordance with the terms of the Deed of Gift.

| | £ | s. | d. | | £ | s. | d. |
|---|---|---|---|---|---|---|---|
| 1936 Jan. 1. Balance of Fund ... ... ... | 20 | 1 | 7 | 1936 June. Lecture Fee | 50 | 0 | 0 |
| 1936. Dividends, Consolidated 4 per cent. Loan | 40 | 3 | 2 | 1936 Dec. 31. Balance of Fund ... ... ... | 20 | 1 | 7 |
| Donation from General Fund ... ... ... | 9 | 16 | 10 | | | | |
| | £70 | 1 | 7 | | £70 | 1 | 7 |

### CELESTIAL PHOTOGRAPHS

The following have been added to the list of Celestial Photographs reproduced by the Society for sale to Fellows :—

| R.A.S. Serial No. | Ref. No. | |
|---|---|---|
| 492 | I 50. | Nebula N.G.C. 1514, Taurus. Lick Observatory. 36-inch Reflector, *f.l.* 210 inches. 1917 Jan. 14. Exp. 3 h. 45 m. |
| 493 | I 51. | Nebula N.G.C. 2237–8–9, Monoceros. M. de Kerolyr, Forcalquier. 32-inch Reflector, *f.l.* 192 inches. 1936 Jan. 27. Exp. 3 h. |

### PUBLICATIONS OF THE SOCIETY

During the past year the Society has published *Monthly Notices*, vol. **96** ; *Geophysical Supplements*, vol. **3**, Nos. 8, 9 ; and *Memoirs*, vol. **65**, pt. 3.

OBITUARY

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year :—

Fellows :—Frank Arthur Bellamy
Redmond Barton Cafferata
Frances Draper
William Frederick Archdall Ellison
Ambrose T. Flagg
George Forbes
John Knight Fotheringham
Caroline Ellen Furness
John James Lewis Goodridge
James Hartness
Gustavus Adolphus Hemsalech
Charles Vivian Jackson
Alphonso King
James Knight
William James Stewart Lockyer
William Newbold
William Tyler Olcott
William Alfred Parr
Edwin Wilbur Rice
William Schooling
Eber Jachin Sharpe
Arthur Grant Stillhamer
Lorna Mary Swain
Basil Taylour
John Miles Rogers Todd
Robert Rumsey Webb

Associates :—Johannes Franz Hartmann
Friedrich Küstner
Paul Stroobant

FRANK ARTHUR BELLAMY.—There are few astronomers—but a few may be called to mind—who have spent more than half a century in active work in the science. One of them was Frank Bellamy, whose sudden death in February last we now have to record. Those who knew Bellamy intimately know that though his work was only of the kind called routine, not demanding much in the way of initiative, his enthusiasm was unbounded, and his efforts to accomplish it were in his later years of a kind scarcely to be expected of a man at his time of life. A note on a postcard from Bellamy to the writer of this, dated 1932 July 12, may be quoted verbatim as testimony:

"I commenced my 52nd year at observatories in Oxford to-day. Going on with zones 32 and 33. Hooray!" The explanation of the reference to "zones" will emerge later.

Bellamy was born at Oxford on 1863 October 17, the youngest of a family of six. As a lad he was familiar with the Radcliffe Observatory, to which he had access, because his brothers Fredrick and Harry were members of the staff. About the time of the death of Mr. Main, the then Radcliffe Observer, in 1878 May, and the appointment of Mr. Stone in the following year, there happened to be several changes in the staff, and the senior members in 1881 were Mr. Wickham and Mr. Robinson, the latter of whom held his position until the removal of the Radcliffe Observatory from Oxford; the junior member was F. A. Bellamy, who was appointed in 1881 July. Bellamy became an observer with the transit-circle and equatorial, his first recorded observation of an occultation with the latter instrument being dated 1882 August 2, and he continued to do that kind of work and the associated computation, together with routine meteorology, for about ten years; but in 1892 a change took place at the University Observatory when Mr. W. E. Plummer, who had been First Assistant since its foundation, was appointed Director of the Liverpool Observatory, and Frank Bellamy was chosen by Professor Pritchard to complete the number of the staff, the date of his appointment being 1892 September 1. But neither he nor its other member, Mr. C. A. Jenkins, was actually appointed to the position of First Assistant, Professor Pritchard, who was beginning to fail in health, avowing that he wished to leave the choice to his successor. Mr. Jenkins, however, left the observatory before H. H. Turner took up the professorship in 1894 March, so that when that happened Bellamy took precedence over F. W. A. Bennett, who had been appointed on 1893 April 6, and remained senior on the staff throughout Turner's régime.

The work of the University Observatory at this time and for years after was the taking of the photographs, and their measurement and reduction, to form the zone of the *Astrographic Catalogue* with plate-centres at declination 25° to 31° N., and into this work Bellamy threw himself wholeheartedly. Frequent references to the annual reports of the Oxford University Observatory in the *Monthly Notices* might be given to testify to this, but two extracts may suffice. In 1898 Professor Turner wrote:

> "It is a pleasure for the Director to record his appreciation of the admirable way in which Mr. F. A. Bellamy has organised and superintended this important but most laborious piece of work during the year."

And in 1905:

> "In recording the conclusion of this heavy piece of work on the *Astrographic Catalogue* the labours of three persons call for special recognition. Mr. F. A. Bellamy has taken practically all the plates and superintended the whole work throughout with unfailing devotion and care. It is pleasant to be able to mention that the University has conferred upon him the honorary degree of M.A. in acknowledgment of these special services."

The other two persons referred to were the brothers Gray, who had done a great deal of the measuring and reduction, and left the observatory when the Oxford zone was finished, which, excepting some necessary additions and revision, was reported to be the position in 1905. In that year Bellamy went with Professor Turner to Egypt to observe the eclipse of August 30, and took successful photographs of the corona with the 13-inch objective of the Oxford astrographic telescope temporarily mounted. The printing of the *Catalogue* was begun on his return and formed Bellamy's main work in the succeeding years, the seventh and last volume of measures being completed in 1911, and a volume of "discussions" two years later. Then pursuant to Professor Turner's efforts to complete or help the work of the *Astrographic Catalogue* generally, the reduction of the zones allotted to the Vatican Observatory (55° N. to 64° N.) was undertaken by Oxford, the plates being taken and measured at Rome. This work was wholly in the hands of Bellamy's niece, Miss Ethel Bellamy, who was given a definite position on the staff in 1912 on the departure of Mr. H. C. Plummer for Dublin, Bellamy during these years being occupied with other astrographic work connected with the Oxford zone and the transference of the zone that had been allotted to the Santiago Observatory to the Nizamiah Observatory that had been established at Hyderabad. His contribution to the Rome work was merely of the nature of notes. When the tenth and last volume was completed in 1928, with the sanction of his Holiness the Pope a gold medal was received through the Foreign Office for the Director, and duplicate medals in silver for Miss Bellamy and Mr. Bellamy for their work in producing the Vatican Catalogue.

Already, however, a scheme for a new effort to advance the astrographic work was in preparation. The authorities of the Potsdam Observatory had surrendered the zone +32° to +39° immediately north of the Oxford zone that had been allotted to them, and in 1928 Professor Turner made the tentative suggestion that this should be undertaken—in part at least—at the Oxford Observatory. It was suggested at first that this part should have been the zones +32° to +35°, but eventually the zones +32° and +33° were provided for, and it was this that elicited the enthusiastic outcry on the card mentioned at the beginning of this notice. These paragraphs give merely a bare record of the astrographic work done at Oxford, and fail to show the full total of Bellamy's labour on it in the way of revision and catalogue comparison; and it may be added that much of the work of practical instruction connected with the professorship was done by him.

Bellamy, unmarried, lived with his two niecesa quiet life, but sometimes a strenuous one, for the later work necessitated some taking of photographs, and there were occasions when he spent a whole night at the telescope, which must have been a trial for a man of his age. He seldom or never took a holiday away from Oxford except to attend a meeting of the British Association, as he always did, or some similar scientific meeting, for he had other interests besides astronomy and was a member of other societies. He was a keen and active botanist and an authority on foreign stamps, of which he had a large collection that was notable for comprising a number of the local

stamps that were formerly issued by the Oxford colleges but were discontinued in 1885. He also had a collection of periodical philatelic literature, and about the year 1920 he offered this and the stamps to the University. The offer was, however, not accepted, the Hebdomadal Council giving the reason that philately is not a branch of the University studies, and that the collection would have been a source of expense to the University. This decision was criticised adversely by competent persons, who thought that the collection should have found a place in the Bodleian. To the casual acquaintance, and as seemed by his habits of life, Bellamy was of a quiet and peace-loving nature, but he was not without the spirit necessary to assert his opinions. The *Oxford Magazine* for 1931 November 5 contained a vigorous article by Bellamy under the title "A Plea for Astronomy in Oxford," in which he protested against the delay in appointing a professor and the prospect of the conversion of the University Observatory, as he said, into a spectroscopic laboratory.

Professor Turner died on 1930 August 20. Professor Plaskett was appointed at the end of 1931 November, and in 1932 June took charge of the Observatory which by decree of 1930 November had been in the charge of Mr. Bellamy in the interim. The award of the honorary degree of M.A. to his niece, Miss Ethel Bellamy, by the University in 1934 for her work on the Vatican Catalogue and seismology was a great pleasure to him.

He died very suddenly as the effect of an unsuspected heart trouble on 1936 February 15, having been with his nieces at a public meeting on the previous evening, apparently in good health.

Bellamy joined the Society on 1896 February 14. H. P. H.

WILLIAM FREDERICK ARCHDALL ELLISON, the eldest son of the Ven. Humphrey Eakins Ellison, Dean of Ferns, was born in 1864. He was educated by his father and in 1883 he gained a sizarship in classics at Trinity College, Dublin. It is a remarkable fact that his five brothers also won entrance scholarships at Trinity College. In 1886 William became a Scholar of the House, and in the following year graduated with Junior Moderatorships in Classics and Experimental Science. In 1890 he took Holy Orders, being ordained by Bishop Westcott of Durham, and held successively the Curacies of Tudhoe and the Venerable Bede's, Monkwearmouth. In 1894 he took his M.A. and B.D. degrees and won the Elrington Theological Prize in 1895.

In 1899 he returned to Ireland to become Secretary of the Sunday School Society, but in 1902 he gave up this post and accepted the incumbency of Monart, Enniscorthy. Six years later he was appointed to the Rectory of Fethard-on-Sea with Tintern in Wexford, and it was here that he set up his first astronomical observatory and began the work of grinding and polishing specula, in which he showed very great skill. He had become interested in practical optics during his association with Dr. N. Alcock of Dublin, who was afterwards appointed Professor of Physics in McGill University, Montreal; and the interest, once begun, became a dominant factor in his life. The large number of specula he worked—being of excellent figure—gained for

him a wide reputation, and he also successfully undertook the construction and figuring of object-glasses. He contributed optical notes to various publications, but it was especially in his book, *The Amateur's Telescope*, and in his contributions to the *Scientific American's* publication, *Amateur Telescope Making*, that he placed his wide experience at the disposal of others who might be desirous of making their own instruments.

Perhaps it may be said that it was by his optical work that he contributed most to astronomy ; at any rate there must be very many who have gained an acquaintance with the heavens and done work of value by means of the instruments he made, but he also did a good deal in the observational field himself.

In 1918 he was appointed Director of the Armagh Observatory after the death of J. A. Hardcastle, and added to the Observatory equipment his own 18-inch Calver equatorial reflector, which he subsequently presented to the Observatory. He also improved the instrumental equipment by adding a 6-inch refractor with an object-glass of his own figuring. This was specially intended for solar and lunar observations. The 10-inch Grubb refractor was employed in the measurement of double stars, in which he had the assistance of his son Mervyn, and also in the observation of planets. As suggested by his friend the late Rev. T. H. E. C. Espin of Tow Law, his double-star programme included the examination and measurement of the Holmes pairs, and later, when his eyesight made micrometer work troublesome and tedious, the measurement of half the Scheiner (Potsdam) and other doubles was continued by his son. The measures have been communicated to the Society.

Ellison's most important planetary work was on Mars, in which he was particularly interested. Several of his drawings made at the 18-inch reflector are published in the *B.A.A. Mars Memoirs* and in the Mars Reports in *Popular Astronomy* compiled by Professor W. H. Pickering. On 1919 February 28 he had the opportunity of making an observation (similar to that of Barnard at Lick on 1889 November 1) of Saturn's satellite Iapetus when in eclipse by the shadow of the rings. Though the eclipse had been predicted weather conditions generally were so bad that the phenomenon was apparently observed only at Armagh ; and there only partly. When first seen Iapetus was illuminated by sunlight passing through the Cassini division, but faded without disappearing on entering the shadow of ring A. The observations were then interrupted for about 20 minutes, after which the satellite was found to be still visible, though intermittently and with quick changes of brightness at intervals of 2 or 3 minutes. A *gradual* recovery of light followed as the satellite emerged from the shadow of the ring. This observation was valuable as a further confirmation of the translucency of ring A, which had been indicated by the visibility of the ball of the planet through the ring on some photographs taken at Mount Wilson a few years previously, and by the observations of the star B.D. 21° 1714 on 1917 February 9 when it was easily seen by Captain M. A. Ainslie and Mr. J. Knight (working quite independently) during its occultation by the ring.

Ellison was also interested in eclipses. He went to Belgium (field of Waterloo) for that of 1912, to N. Wales for the British Eclipse of 1927, and to Canada for that of 1932, but unfortunately bad weather prevented observations on the two latter occasions. It was he, too, who first noted the fact that the time of the Mediterranean cruise of the P. & O. Company's *Strathaird* in June 1936 would include the date of the solar eclipse and that the vessel would be on, or close to, the central line off the coast of Greece on the morning of the event (19th). A large number of astronomers, including Ellison himself, accordingly took advantage of the cruise, and—the ship's company and officers kindly providing every facility—observed the eclipse from the *Strathaird's* decks under absolutely ideal conditions of weather and sea.

Though in charge of Armagh Observatory he continued his regular clerical work—holding the incumbency of Kildarton. In 1934 he was appointed Canon and Prebendary of Ballymore, Armagh Cathedral. He was a noted Hebrew scholar, and his translations of the Psalms from the original sources and other works by him were well known to the clergy of the Church of Ireland. He was gifted, too, with a remarkable memory, and it was impossible to be long in his company without being impressed by the breadth and soundness of his general knowledge. He became quite a character in Irish life, largely through his direct and forcible letters to the press on all sorts of subjects, scientific, literary and otherwise. He had a gift for humorous poetry, and some of his poetical satires on Irish questions gained him not a little notoriety. Music was a great recreation to him, and for many years he played several hours a week on the great organ of Armagh Cathedral. Living in Armagh he was largely isolated from personal association with men of like interests, but this was in part compensated by a large correspondence with scientific friends in all parts of the world. He was a Member of the Royal Irish Academy, Fellow of the Royal Meteorological Society, Membre de la Société Astronomique de France, Member of the British Astronomical Association, and a contributing editor of the *Scientific American.*

Canon Ellison married first in 1895 Elizabeth Havelock, daughter of Joseph J. C. Blackburn and grand-niece of General Sir Henry Havelock of Lucknow. By her he had three sons, the eldest of whom was killed in the Great War. He married, secondly, in 1934 Kathleen, daughter of the late F. R. Sproule of Dublin.

He is survived by his widow and two sons, Henry Havelock Ellison of Elstree, and Mervyn Archdall Ellison of Sherborne School, Dorset. To the latter the writer of this note is indebted for most of the details of Canon Ellison's life.

He was elected a Fellow of the Society on 1918 February 8.

T. E. R. P.

AMBROSE T. FLAGG was born at Greenwich on 1851 October 5. He was a graduate of Christ's College, Cambridge, and after serving for some time on the staff of King's College, London, he was appointed headmaster

of the South Shields Marine School in 1886 May, a post which he held for fourteen years. He was for several years a member of the South Shields Education Committee, and took a prominent part in various local activities.

He died at Chapel House, Westoe Village, South Shields, on 1936 April 26.

He was elected a Fellow of the Society on 1901 January 11.

By the death of GEORGE FORBES the Society loses one of its oldest Fellows. He had a varied history as traveller, war correspondent, inventor, electrical engineer and astronomer. His most important work was the part he took in the power-station of Niagara. Astronomers are indebted to him for an admirable life of David Gill.

George Forbes was the second son of James David Forbes, a physicist well known for his discovery of the viscous motion of glaciers. He was born in Edinburgh on 1849 April 5, where his father held the Chair of Natural Philosophy. He was educated at St. Andrews, when his father in 1859 became Principal of the University, and later at Christ's College, Cambridge. He was awarded an *ægrotat* degree in the Mathematical Tripos of 1871 owing to illness at the time of the examination. From 1872 to 1880 he was Professor of Experimental Philosophy at Anderson's College, Glasgow. In 1874 he took part in one of the expeditions organised by Airy to observe the Transit of Venus. He accompanied Captain (afterwards Colonel) Tupman, who was in charge of the expedition to Honolulu. Forbes left Honolulu on November 5 to take charge of a station at Kailua, on the island of Hawaii. He successfully observed the Ingress of Venus on December 8. He had a narrow escape of his life in a gallant attempt to save the life of a colleague while they were bathing in a heavy surf. From Honolulu he went to Pekin, and in the course of an adventurous journey across the desert of Gobi and through Siberia was able to secure the release of a pair of Siberian exiles from Irkutsk. In 1877 he acted as the *Times* war correspondent with the Russian army in Asia in the Russo-Turkish War. He had great difficulties in getting the necessary permission, but in the end succeeded and had the honour of wearing his war correspondent's badge on the Ribbon of the Order of St. George. A very interesting account is given by him in the *Times* for 1930 February 20 and 21.

Towards the end of his period at Anderson's College, in conjunction with Professor Young he determined the velocity of light by a slight modification of Fizeau's method. They found the velocity of blue light was 1 per cent. greater than that of red light, but afterwards admitted that this result was not reliable (*Phil. Trans.*, **173**, 231, 1883).

For the next twenty years Forbes was an electrical engineer. Like many other engineers he worked at the improvement of the dynamo, and showed a machine of his design at the Philadelphia Electrical Exhibition of 1884. In 1890, under the Chairmanship of Lord Kelvin various firms were invited to submit schemes for the utilisation of the falls of Niagara for the production and distribution of power. Forbes proposed polyphase current of low frequency. Direct current was, however, decided upon, but Forbes was

given a premium for his proposal and appointed one of the consulting engineers of the Company. In 1897–98 he was employed by the Egyptian Government to survey the cataracts of the Nile with a view to their use as electric power for the Nile railway. He published several works on electrical subjects.

The astronomical problem to which Forbes gave much thought was an attempt to find an ultra-Neptunian planet. In 1880 he published in the *Proceedings* of the Royal Society of Edinburgh a paper with the title "Comets and Ultra-Neptunian Planets," and gave an abstract in the *Observatory* magazine. From the analogy of the comets associated with Jupiter he looked for a similar relationship between seven comets whose distances at aphelia were between 96 and 124 astronomical units. Marking their positions on a globe, he found that four of them were in one plane. He took this plane for the orbit of a planet at distance 100 units with a period of 1000 years, and found that it passed sufficiently near the positions of the comets at their aphelia for them to come under its attraction. He found additional support for this somewhat speculative theory by the failure to return in 1848 of the bright comet of 1556 which was supposed to be identical with that of 1264. In *Monthly Notices*, December 1908, he suggested that this comet had been broken up into three parts, the comets of 1843, 1880, and 1882, as the orbits of these comets showed a nearly identical position at aphelion. With these additional data he computed the following elements for the unknown planet :—

| $\Omega$ | $i$ | $e$ | $\pi$ | $a$ | $P$ | Perihelion Passage |
|---|---|---|---|---|---|---|
| ° | ° ′ ″ | | ° | | | |
| 247·34 | 52 0 30 | 0·1665 | 114·57 | 105·1 | 1076 | A.D. 1072 |

From these elements an ephemeris was computed and a photographic search made by Hough at the Cape Observatory, but in vain.

From the year 1920 he was interested in clocks, and made designs for a half-seconds pendulum of fused silica, but in view of the improvements in clocks made about this time, did not construct such a clock.

Forbes became acquainted with Gill between 1869 and 1871, and met him again at the meeting of the Astronomische Gesellschaft in 1873. He stayed with Gill on two occasions in South Africa, and saw him frequently after his return to England. Shortly after Gill's death he wrote a life of his friend in which he gives a true and vivid picture of the enthusiasm and energy which Gill threw into his work and play, and it is an admirable biography. Among Forbes's other books may be mentioned *A History of Astronomy*, published in 1909, and *Puppets: A Work-a-day Philosophy*, in 1911.

Forbes was elected a Fellow of the Royal Society in 1887, and a Fellow of the Royal Astronomical Society on 1873 January 10. F. W. D.

JOHN KNIGHT FOTHERINGHAM, who was born on 1874 August 14, was not originally an astronomer or mathematician, but an historian. He was an exhibitioner of Merton College and took Second Class Honours in Classical Moderations in 1894, and First Class Honours in Literæ Humaniores

in 1896, and in Modern History in 1897. From 1898 to 1902 he held a Senior Demyship at Magdalen College and it was during this period that he began to study Ancient Chronology. In 1904 he became Lecturer in Classical Literature at King's College, London, and eventually he was appointed Reader in Ancient History in the University of London. He remained an active teacher at King's College till 1915.

In the course of his chronological studies he soon found that many historians were falling into obvious errors through astronomical misunderstanding and he began to pay attention to mathematical astronomy itself. This line of activity brought Fotheringham into touch with Mr., now Dr., Cowell. At the time (1906) Cowell was writing his papers on ancient eclipses. Fotheringham freely placed at Cowell's disposal his knowledge of ancient literature in its bearings on chronology, and Cowell initiated Fotheringham into the technical aspects of such astronomy as entered into the use of eclipses to determine the motions of the Sun and Moon. Fotheringham also received a great deal of encouragement from H. H. Turner, and it was not long before he began to write astronomical papers himself. Some of his early papers, the first of which appeared in 1908, were concerned with astronomical chronology, including the conditions of the visibility of the lunar crescent to the naked eye. But he had found a sphere of his own in strictly astronomical research and he began a series of papers on the lunar and solar accelerations as determined from different classes of observations. This work culminated in 1920, when he arrived at the definite conclusion that all classes of ancient observations comprising lunar and solar eclipses, occultations, and observations of the time of passage of the Sun across the equator, were adequately satisfied by a secular acceleration of the Sun of $3''{\cdot}0/(\text{century})^2$ and a secular acceleration of the Moon of $21''{\cdot}6/(\text{century})^2$.*

This important result has been discussed by Jeffreys. Subtracting from the lunar acceleration the part predicted by the lunar theory, the residue consisting of $9''{\cdot}4/(\text{century})^2$ for the Moon as well as the full acceleration of $3''{\cdot}0/(\text{century})^2$ for the Sun should be attributable to the action of tidal friction. But there are theoretical difficulties here for accepting the value for the Moon, the theory of tidal friction then gives an upper limit of $1''{\cdot}26/(\text{century})^2$ for the acceleration of the Sun. This is considerably lower than the observed value, and it appears that the difference is too large to be ascribable to the error of the observational determination. It seems as if some unexplained cause were effective.

In the meanwhile Fotheringham had been elected in 1909 to a Research Fellowship at Magdalen College on condition of undertaking to make and prepare for publication a critical edition of Jerome's Latin version of the *Chronica* of Eusebius, a task which was duly performed. His Fellowship expired in 1916 at a time when his work at King's College had been suspended by the War. This left him without income and without duties. After spending some months in a Government office from which he had to retire owing to ill-health, and subsequently producing an astronomical paper as a

* The actual figures given by Fotheringham were half these, as he gives the coefficients of $T^2$ in the longitudes.

recreation during convalescence, Fotheringham was glad to accept a post as Temporary Assistant at the University Observatory at Oxford at a stipend of £100 a year. The appointment was renewed from time to time and the stipend was ultimately raised to £252 a year. In 1925 he was appointed Reader in Ancient Astronomy and Chronology at Oxford. The stipend was moderate (£300 per annum) but this circumstance did not prevent Fotheringham from working with his accustomed energy, and during the last decade of his life he produced a large output of work, astronomical, chronological, and historical. He was responsible during this period for the appearance of papers in which he brought out certain apparent deviations from gravitational theory in the motions of the Moon and planets. His interpretation of the deviations did not meet with general agreement, but the work he did to exhibit them was of undoubted value.

We have it on the authority of his brother that in his own mind Fotheringham was disposed to explain the fluctuations in the motions of the members of the Solar System by regarding the Sun as the core of a large surrounding envelope of extremely tenuous matter extending to at least a hundred million miles. He once spoke of the planets as "ploughing their way like ships through a stormy sea," and he regarded comets as showing both by their motions and by their disintegration the effect of this envelope. According to him, the envelope rotated with the Earth and planets and so its effect was magnified for bodies moving in eccentric orbits, such as comets.

Fotheringham was a keen controversialist but at the same time a very lovable man. By his death, on 1936 December 12, the Society has lost one of its more striking personalities. He was elected a Fellow on 1910 February 11. W. M. H. G.

CAROLINE ELLEN FURNESS was born in Cleveland, Ohio, on 1869 June 24. She received her early education in the public schools of Cincinnati, and in due course she obtained a four-years' scholarship at Vassar College. It was there that she came into association with Mary Whitney, the Director of the Observatory, whose influence affected the course of Miss Furness's subsequent career.

After graduation Miss Furness held high school posts for three years, but in 1894 she returned to Vassar as an assistant in the Observatory. The early programme of the Observatory was performed entirely by Miss Whitney and Miss Furness, and consisted of micrometrical observations of comets and minor planets with the 12-inch refractor. In 1900 Miss Furness took her Ph.D. degree, her thesis being "Catalogue of Stars within 1° of the North Pole, and Optical Distortion of the Helsingfors Astrographic Objective." This thesis was published in 1900 as a Publication of the Vassar Observatory. It had been executed under the supervision of Harold Jacoby of Columbia, who had in his possession twelve overlapping plates of the north polar region, which had been taken for him at Helsingfors. The catalogue was subsequently extended by graduates of Vassar under the direction of Miss Furness, and in 1905 the extended catalogue, comprising 408 stars within 2° of the Pole, was published.

In the meanwhile the observation of variable stars had become the principal activity of the Vassar College Observatory. The observations were made with a wedge photometer attached to the 12-inch, and the programme was begun by Miss Whitney in 1901. From 1909 onwards Miss Furness collaborated in the work. In 1911 she became the acting Director of the Observatory through the illness of Miss Whitney, and was at the same time appointed to an associate professorship. It fell to her lot to edit the Variable Star Results which appeared in 1913 as No. 3 of the Observatory Publications. In the same year (1913) she was appointed Director of the Observatory, and her book, *An Introduction to the Study of Variable Stars*, made its appearance in 1915. In 1916 she became Maria Mitchell Professor of Astronomy.

From that time until the failure of her health in the summer of 1935 Professor Furness remained in active direction of the Vassar College Observatory. She was responsible for the arrangements made there for observing the eclipse of 1925 January 24. In the autumn of 1934, while on a sabbatical year, she began a study, at Mount Wilson, of the infra-red solar spectrum, but her failing health interrupted this project.

Miss Furness enjoyed the reputation of being in the front rank of the teaching profession, and was a devoted friend to her students and colleagues.

She died on 1936 February 9.

She was elected a Fellow of the Society on 1922 June 9.

JOHN JAMES LEWIS GOODRIDGE died at the age of eighty at his residence, 77 Avenue Road, Southampton, on 1936 March 13. He was a retired master mariner and Trinity House pilot. He bequeathed a legacy to the Society, to which he had been elected a Fellow on 1889 January 11. He was a bachelor.

CHARLES VIVIAN JACKSON, whose death at the early age of thirty occurred as the result of a sleigh accident in Switzerland in 1936 December, was known in astronomical circles by his contributions to the establishment of accurate standards of wave-length by interferometric measurements. He was born in London on 1906 June 23, his father being the late Sir Charles Jackson. He was educated at Rugby School, and afterwards at Oriel College, Oxford, where he took an Honours Degree in Physics. He was specially attracted by the precision of spectroscopic measurements, and after graduation undertook research in this work, first at Oxford and afterwards at the Imperial College, South Kensington, where he received an appointment as Honorary Lecturer. A man of considerable wealth, he was able to purchase instruments of the highest quality, which he used with great skill, and his measurements of standard wave-lengths were published in a series of papers, mostly in the *Proceedings of the Royal Society*. He was a member of the Wave-lengths Commission (No. 14) of the International Astronomical Union, and attended the meetings in Paris in 1935. Jackson's early death removes a worker of considerable distinction from this important field, and his contributions will be seriously

missed. He was twice married, his second wife, who with one son survives him, being Stella Winn, daughter of Lord Newborough.

He was elected a Fellow of the Society on 1930 May 9.

ALPHONSO KING was typically one of those amateurs who by working in a narrow field are able materially to advance their chosen line of study. He was born on 1882 January 17, and while still young had begun to record the paths of meteors; by 1898, at the age of sixteen, he was a regular member of the comparatively strong group of observers then working in this field, and he continued regular observation down to the end of 1905. For some years thereafter he made only occasional records, but in 1919 he resumed regular observing, which he then carried on until shortly before his death. In this admittedly difficult branch of observation King was a skilful worker, but he does not seem to have had the opportunity of carrying on the long watches needful for the most successful work, and it is probable that he did not influence the development of the subject to the extent that his skill as an observer made possible. This, however, does not imply that he did not make many valuable observations, particularly of the major showers, where his work was most effective. His most important contribution to meteor astronomy, however, was his computing work, which he first seriously undertook about 1922 and which steadily increased in volume. From 1929 onwards he was responsible for the whole of the computing for the Meteor Section of the British Astronomical Association, and computed the paths of several hundred meteors with a painstaking care that was typical of him. In addition he undertook the computation of the paths of all casually seen fireballs that came to his notice, including the writing of long letters to the untrained observers explaining what information he wanted. This work was often disappointing, and it was not unusual for him to have no satisfactory solution to show as the result of many hours of work. How much of his leisure this work absorbed it is impossible to say, but in recent years he would often begin computing in the early evening and continue until past midnight. His notebooks, which since his death have come into the possession of the writer of this notice, only confirm what we already knew of his care and energy; nothing came amiss to him, and it is perhaps typical of him that the last entry in his notebooks is the heading, "Detonating Fireball over Palestine, 1935 July 1."

This computation was never finished. Early in 1936 he had a severe illness, from which he seemed to be making a slow recovery; he wrote in mid-March that he was better, and looking forward to resuming work, but this hope was not fulfilled, and he died on 1936 April 18 aged fifty-four. He married in 1920 Miss Rose Tozer, who survives him. He was a schoolmaster by profession, and at the time of his death had been for over thirty years a master at the Council School at Ashby, North Lincolnshire. His published work includes his Catalogue of Radiants, 1898–1915 (*M.N.*, **76**, 542, 1916), and a number of papers on meteor showers and fireballs principally in the *Monthly Notices* and in the *Journal of the British Astronomical Association*. Both as an observer and as a computer he made notable

contributions to the study of meteors; but more than this he helped the younger generation of meteor workers by his unfailing encouragement and by his knowledge and sound judgment, which made him—the only active survivor of the old group of meteor workers—the teacher and helper of those to-day carrying on that work.

He was elected a Fellow of the Society on 1903 April 8.

J. P. M. P.

JAMES KNIGHT was born in Glasgow on 1860 June 22. He took a course of training in the Glasgow Free Church Training College for Teachers, and also studied at Glasgow University, where he graduated M.A. in 1882, B.Sc. in 1884, and D.Sc. in 1903. At the University he gained prizes in many subjects and the Hunterian Medal in Geology, while he also won nine diplomas of the Science and Art Department. For forty-five years he was a teacher in his native city, twenty-two years of that period being spent in secondary schools. In the last five years of his service he was head of Queen's Park Secondary School. He was highly respected by his pupils and by his fellow-members of the teaching profession.

Dr. Knight's outstanding characteristics were his remarkable activity and enthusiasm, and the extraordinarily wide range of his interest and knowledge in scientific subjects. At meetings of scientists, whatever might be the matter of discussion, he was always able to offer interesting and illuminating comment. He was long one of the most prominent members of the Royal Philosophical Society of Glasgow. At his death he held the offices of Vice-President of the Society, and President of its Geographical Section. From 1907 continuously he was Honorary Librarian, and to his unwearied services and wise discrimination is due the present high value of the Society's library. He was much interested in music, and from 1916 to 1918 he was Lieut.-Colonel of the Glasgow Cadets. He published books and pamphlets on a variety of subjects.

On certain occasions Dr. Knight made much appreciated contributions to the *Proceedings* of the West of Scotland Branch of the British Astronomical Association. During the last few years he gave lectures on Astronomy under the "David Elder" foundation in the Royal Technical College, Glasgow, the last of such lectures being delivered within a fortnight of his death. He died on 1936 December 1 at his residence at Uddingston.

He was elected a Fellow of the Society on 1932 January 8. J. J. R.

WILLIAM JAMES STEWART LOCKYER, fifth son of Sir Norman Lockyer, was born 1868 January 3, and died suddenly 1936 July 15 as he was walking homeward from the Observatory at Sidmouth.

From the first he seems to have been destined to a scientific career. He was educated at Cheltenham and Trinity College, Cambridge. Then, after a time at the Royal College of Science, South Kensington, he went on to Göttingen. In his thesis (1896) for the doctorate he gave a painstaking discussion of all the available observations of the variable $\eta$ Aquilæ.

Thus equipped by a training which had been remarkably broad, Dr.

Lockyer joined his father's staff at South Kensington, and in the next twelve years or so imbibed the spirit, if not the originality, of that great pioneer. The association with his father guided his work in two particular directions. At first in a subordinate and later in a directing capacity, he took part in at least nine eclipse expeditions, beginning with Vadsö (Lapland) in 1896, and ending in Canada in 1932. In the early days of the century Sir Norman Lockyer gave much attention to those large-scale meteorological phenomena which may be associated with solar changes. At his instigation the International Meteorological Committee appointed a committee in 1903 to study the subject, with Dr. Lockyer as secretary. The papers of father and son opened up aspects then comparatively new, and incidentally revealed the lack of co-ordinated data on a sufficiently wide scale, thus showing the way to an improved modern organization of the observations. The Indian rainfall, sympathetic changes of barometric pressure at widely separated stations and their relation to the sunspot period and the Brückner cycle are among the main topics discussed in this attempt to make meteorology throw light on solar physics.

The active life at South Kensington came to an end about 1910, when Sir Norman Lockyer retired on account of age. Not without bitter opposition he had persuaded the Government to build up the solar physics observatory at the Royal College of Science. On his retirement the equipment was transferred to Cambridge, and he was not alone in regretting the decision. Active friends came to the rescue as far as that was possible, and in 1913 the Hill Observatory at Salcombe Regis, Sidmouth, came into existence. In 1920 Sir Norman died, and his son became the director of the institution, now renamed the Norman Lockyer Observatory. With modest equipment and limited assistance, Dr. Lockyer has maintained by his zeal and energy a high level of activity, of which the evidence is to be seen in the publications of the Society.

Apart from his scientific career, Lockyer had early become "air-minded," a fact which determined the part he took in the War. In 1907 he made his first balloon ascent with the Hon. C. S. Rolls, and in association with Sir F. K. McClean became actively interested in the development of aeroplanes. As lieutenant R.N.V.R. he was attached to the Royal Naval Air Service in 1915, promoted lieutenant-commander two years later, and became major, R.A.F., in 1918. His service before retirement in 1919 had been varied and responsible. He was a member of the Royal Aero Club, and his interest in all matters pertaining to flying remained keen to the end.

Jim Lockyer, as he was known to his intimates, possessed a frank, open nature which endeared him to a wide circle of friends. As an astronomer he belonged essentially to the type of observer, active at the telescope and a skilled photographer. With more liberal opportunities he might have done even better work, but it was characteristic of him that he was ever ready to do what was possible with the means which lay at hand. He carried a great tradition, and with something of the outlook of a past generation he combined a youthfulness, almost a boyishness, which did not desert him to the end. With the more speculative and the deeper sides of astronomy

he was not greatly concerned. But his devotion to the interests of science in general was as keen as it was disinterested.

Dr. Lockyer had served on the Council of the Society from 1927 to the time of his death, with the exception of the years 1929–31 ; he was Vice-President 1933–35. His fellowship dated from 1897 December 10.

At the age of eleven he had the misfortune to lose his mother, and this gap in the family life was not filled till his father married the present Lady Lockyer in 1903. Dr. Lockyer himself comparatively late in life married in 1921 Kate Irene, widow of the late W. S. Wright, and leaves no children. It is greatly to be hoped that the Observatory on Salcombe Hill will long continue to preserve the family name and tradition.

H. C. P.

WILLIAM NEWBOLD was born at Tunbridge Wells on 1878 June 17, the eldest son of the eleven children of the late William Newbold, 7 Broadwater Down, Tunbridge Wells. He was educated at Uppingham School and Magdalen College, Oxford. He obtained a First Class in Classical Honour Moderations in 1899 and a Second in Litt. Hum. in 1901. After taking his degree he joined the staff of Tonbridge School as a classical form-master in 1902 September. Five or six years later he began to teach mathematics, and for the last half of his teaching career at Tonbridge he was responsible for an army class and taught only mathematics.

He was interested in astronomy from his boyhood, and as an undergraduate acquired a $2\frac{3}{4}$-inch Troughton & Simms refractor, with the aid of which and Webb's *Celestial Objects for Common Telescopes* he became familiar with all the easier items of interest in the northern skies. He was at the time offered by a friend a $3\frac{1}{2}$-inch Steward equatorial, but had no means of mounting or housing it. At Tonbridge School, however, he found an empty observatory used as a store for the provender of the school horse. He was thus enabled to accept the gift of the Steward equatorial and install it conveniently. A voluntary astronomical class was formed which he conducted until the War.

In 1905 August he took the Steward instrument to Philippeville in Algeria, where he had an uninterrupted view of the total solar eclipse. A year later he finally dismantled his own telescope when the school observatory was enlarged to receive a 6-inch Cooke equatorial, the gift of the Hartree family. This instrument was thereafter until the War in constant use by himself personally and by members of his astronomical class. In the autumn of 1910 he was given a term's leave of absence to visit Canada and the United States, in the course of which he saw many well-known observatories, including the Dominion Observatory, Ottawa ; Mount Wilson, Lick, Flagstaff, Harvard, and the Naval Observatory, Washington. In each case he had the good fortune to be shown the equipment by the Director in charge.

He received a Commission in the R.G.A. in 1914 December, and early in 1915 February joined the 119th Heavy Battery in France, which a few weeks later took part in the battle of Neuve Chapelle. After some fifteen

months with this battery he was promoted Captain, and joined the artillery section of the Field Survey unit of the Third Army then in process of development. For the next two and a half years he served continuously with the Field Survey organisation of the Third Army, reaching the rank of Major and receiving the military O.B.E. and three mentions in dispatches.

After the Armistice he spent a few months at G.H.Q. in the task of collecting and classifying specimens of Field Survey work for purposes of army records, and on demobilisation he was appointed H.M. Inspector of Secondary Schools under the Board of Education. For the next twelve years he had a West Riding district and lived in Leeds. For the last five years of his life his transfer to a southern district enabled him to live at his mother's home at Imberley Lodge, East Grinstead, where he died on 1936 June 24.

After the War his astronomical interests became overshadowed by statistical hobbies, for which his work for the Board of Education provided much varied material, and in the last ten years of his life he became keenly interested in all branches of biology and dabbled a great deal in aquatic microscopy. One of his annual recreations was to evaluate $\pi$ from the distribution of scores in the Open Golf Championship. The result was rarely wrong by more than one or two units in the third significant figure. In his statistical investigations he received much assistance from his sister, the late Dr. Ethel Newbold, who was a member of the Statistical Staff of the Medical Research Council.

He was a very human and tolerant person, and was particularly fond of children, and they of him, especially boys with scientific hobbies, many of whom, both in Yorkshire and Sussex, he helped unobtrusively with advice and gifts.

He was elected a Fellow of the Society on 1904 December 9. D. N.

WILLIAM TYLER OLCOTT was born in Chicago on 1873 January 11. His family moved to Norwich, Connecticut, whilst he was a boy, and in due course he graduated from Trinity College at Hartford, Connecticut. Later he attended the New York Law School, and was admitted to practise before the Bars of New York and Connecticut. In 1902 he married Clara Hyde of Yantic, Connecticut, who survives him.

The year 1905 saw the commencement of Olcott's interest in astronomy, and in 1907 there appeared the first edition of *A Field Book of the Stars*. This was followed by other books, including *Star Lore of all Ages*, *Sun Lore of all Ages* and *Field Book of the Skies*, the last being published in 1931. In 1910 Olcott became acquainted with E. C. Pickering, then Director of Harvard Observatory. Pickering stressed the need of more observational data on the long period variables, and suggested that it would be met by the organisation of amateur effort. Within a year Olcott had collected a small band of observers who became the nucleus of the American Association of Variable Star Observers.

The formal incorporation of the Association under the laws of Massachusetts did not come till 1917. Olcott became the life-secretary of the

organisation he had founded, and it is largely due to his efforts that the Association has attained the high reputation it now enjoys. It still maintains its connection with the Harvard College Observatory, and comprises over 300 members who, located in many countries, contribute regularly a large mass of observational material.

Olcott was never robust, and for years he suffered from bronchial ailments. He was a kindly, patient man, and was characterised by a painstaking attention to matters of detail. His position as Secretary to the Association of Variable Star Observers entailed a large mass of correspondence, and it was his boast that no letter remained unanswered for longer than twenty-four hours. He was devoted to his science, and leaves a notable memorial to himself in the Association for whose inception and development he was responsible.

He died on 1936 July 6.

He was elected a Fellow of the Society on 1926 February 12.

WILLIAM ALFRED PARR, the son of William Parr, a London merchant in the East India trade, was born in Hampstead. Educated at first at home he spent his later schooldays at Stuttgart, afterwards taking his Ph.D. degree at the University of Berlin. For a short time he followed a business career, being employed in the London agency of the Deutsche Bank. But he had long desired to adopt music as a profession, and he soon returned to Berlin to secure the necessary training. On obtaining his diploma he went to live in Florence, where he practised the profession of teacher of the piano until 1910. In that year he returned to Hampstead, where he continued his teaching work until 1914.

During the Great War he was employed in the Censor's department at the Post Office, and after the conclusion of hostilities was appointed foreign science reader and librarian to Messrs. Vickers Ltd. He retired from this post at the end of 1932. In 1927 he had moved from Hampstead to St. Albans, and here he died on 1936 April 2.

Parr's interest in astronomy dated from his early schooldays, and was second only to music in the place which it occupied in his thoughts throughout his life. Starting with a small hand-telescope, he eventually acquired a 4-inch photovisual refractor by Cooke. This instrument, on a clock-driven equatorial mounting, he erected first at Hampstead, and latterly, under a small dome, in his garden at St. Albans. He used it chiefly for occasional observations of sunspots and prominences, solar work having always had a particular fascination for him. At his death he bequeathed the entire observatory and its equipment to the St. Albans High School for Girls.

It was in the literary and historical side of astronomy that Parr's interest was chiefly centred. Here his great knowledge of modern languages, acquired during his long sojourns on the Continent, were of particular value to him, both in his own reading and in the help which it enabled him to give to others. His services as an interpreter, whether of the written or spoken word, were always at the disposal of his friends, many of whom will

recollect his good offices in this connection at the Rome meeting of the I.A.U. in 1922.

Parr served for many years as honorary librarian to the British Astronomical Association. Here he found work which was thoroughly congenial to him, and for which, by reason of his special gifts and attainments, he was admirably suited. His services to the Association were fittingly recognised by his election to the Presidential chair in 1932, and it was a great satisfaction to him that he was able to complete his term of office before he was overtaken by the illness which led to his death.

He was elected a Fellow of the Society on 1913 April 11, and served for a time on the Council's Library Committee.

He leaves a widow and one son, the Rev. Cecil Parr. W. H. S.

EDWIN WILBUR RICE was born in La Crosse, Wisconsin, U.S.A., on 1862 May 6. His family subsequently moved to Philadelphia, where, as a schoolboy, Rice came into contact with Professor Elihu Thomson, at that time a teacher in a High School. In 1880 Thomson left the teaching profession to go into the electrical industry, and young Rice gladly accepted an opportunity to become his assistant. In 1883 he went with Thomson to Lynn, Massachusetts, upon the formation of the Thomson-Houston Company, and at the age of twenty-two Rice became plant superintendent of the company, a position which he held until the consolidation in 1892 of the Thomson-Houston and the Edison General Electric to form the present General Electric Company. In the new company Rice was first made technical director, and in 1896 he became vice-president in charge of manufacturing and engineering. In 1913 he became the president of the company, a position which he held till 1922, when he retired and was made honorary chairman of the Board.

His home since 1894 had been in Schenectady, New York, where he was a trustee of Union College. He was keenly interested in the physical sciences, and he was largely responsible for the establishment of the General Electric Research Laboratory, having recommended that step to the directors in 1900. He contributed materially to the organisation and technical development of his company, and was a promoter of many methods of advancing the welfare of its employees. He was a generous benefactor to Union College.

In 1884 Rice married Helen K. Doen of New Britain, Connecticut, and subsequent to her death he married her sister Alice in 1897. He is survived by her and by two sons and a daughter.

He died at his home on 1935 November 25.

He was elected a Fellow of the Society on 1934 January 12.

SIR WILLIAM SCHOOLING died in a nursing home at Virginia Water on 1936 February 18. By his death the Society lost a Fellow whose initiative and generosity were responsible for one of the pleasing features of our Meeting Room as it is to-day. From the Council Minutes for 1892 November we learn that Mr. Schooling had prepared a series of photographs of the Presidents of the Society, which he proposed to make as complete as

possible, and to present to the Society. The thanks of the Council were unanimously voted to Mr. Schooling for his valuable gift.

This was the beginning of the series of Presidents' portraits now hung in the Meeting Room. As far as can be gathered the portraits presented by Schooling ranged from Colebrooke (1823) to Dunkin (1886), with the exception of Lord Lindsay (1878–1880). The series has been extended, and is a much valued possession.

Schooling, who was born on 1860 December 16, established for himself a very wide reputation as a journalistic expert on insurance matters, and as a popular exponent of statistical problems. He placed his attainments at the disposal of the Government when the War Savings Committee was formed, and for many years he gave his services to it and to its successor, the National Savings Committee. The Savings Certificate is now well established as a beautifully simple security, and has been imitated in many countries. In its initiation Schooling's technical knowledge was of the greatest value. He devoted himself with enormous zeal to the Savings Movement, and was made a C.B.E. in 1918 and K.B.E. in 1920.

He was keenly interested in astronomy and in other aspects of scientific research, and was elected a Fellow of the Society on 1899 January 11. He was the author of a brief note in the *Monthly Notices* (**50**, 401, 1890), which describes an ingenious device. But his writings naturally dealt mainly with other subjects. He published works on *Value for Money* and *Life Assurance Explained*, and technical expositions of interest tables.

Schooling married in 1886. He survived his wife, who died in 1930. He was essentially a man who did his utmost for the benefit, as he conceived it, of the community.

EBER JACHIN SHARPE was born at Ramsgate, Kent, on 1861 January 9. He followed the profession of the sea, and in due course became a Master Mariner. He was a younger Brother of Trinity House, and a Nautical Surveyor to the Board of Trade. During the Great War of 1914 to 1918 he was appointed for special service to the port of Swansea, and retired therefrom to his old home at Ramsgate.

He was keenly interested in astronomy, and was elected a Fellow of the Society on 1904 February 12. He died on 1936 August 14, and is survived by his widow, Philadelphia Rhoda, only daughter of Walter Booth. He leaves six daughters and one son.

ARTHUR GRANT STILLHAMER was born at Bloomington, Illinois, on 1878 February 26. He graduated at Illinois Wesleyan University in 1898, and eventually became Professor of Physics at the same university. He was on the staff of the Yerkes Observatory for approximately one year in 1905–1906, at which time he temporarily filled the place of Dr. Philip Fox who was absent in Europe. During his stay at the observatory Stillhamer was in charge of the Solar work, doing experimental work in direct photography of the Sun, and in observing with the Rumford spectroheliograph. He died on 1936 February 5.

He was elected a Fellow of the Society on 1906 November 9.

LORNA MARY SWAIN was the daughter of Mr. Edward Swain of Mountfield Road, Finchley, and was born on 1891 March 3. She entered Newnham College, Cambridge, as a mathematical scholar in 1910, and was placed as a wrangler in part two of the Mathematical Tripos in 1913. She satisfied the examiners in Schedule B. In 1914 she was appointed an Assistant Lecturer at Newnham, but deferred taking up the appointment, and went to Göttingen for further study. Her stay there was, however, interrupted by the outbreak of the Great War.

In 1915, after a short period spent at the University of Manchester, Miss Swain took up her appointment at Newnham, where she subsequently held the positions of Lecturer and Director of Studies in Mathematics. Her stay at Newnham was twice broken, once in 1918–19, when she was granted a year's leave of absence for research at the Royal Aircraft Establishment, Farnborough, and again in 1928–29, when she spent a vacation in research work at Göttingen. Her publications included papers on Mechanics and Hydrodynamics. She died on 1936 May 8.

She was elected a Fellow of the Society on 1922 December 8.

BASIL REGINALD HAMILTON TAYLOUR (who restored the spelling of his family name by deed poll in 1915 to conform to that of the head of his house, the Marquess of Headfort) was the son of the Right Honourable T. E. Taylor, P.C., M.P., of Ardgillan Castle, County Dublin. His mother was Louisa, daughter of the Hon. H. F. Tollemache. He was born in 1865, and educated at Cheam School and H.M.S. *Britannia*. He entered the Navy in 1879, and as a lad of seventeen he had his baptism of fire at the bombardment of Alexandria in 1882, and landed with the Naval Brigade in the Egyptian Campaign of that year. In 1894 he made observations of the Transit of Mercury, the results of which appeared in the *Monthly Notices* for 1894 December. Taylour was at that time a lieutenant attached to H.M.S. *Blake* on the North American Station, and his observations of the Transit on November 10 were made with a $2\frac{1}{4}$-inch refractor on a tripod stand. He was elected a Fellow of the Society on December 14 of the same year, his proposer being Sir Josiah Rees, Chief Justice of Bermuda. During his naval career he took part in an expedition to Northern Japan to observe a total eclipse of the Sun.

In 1899 Taylour resigned his commission in the Navy (but later rejoined the emergency list with the rank of commander), and was appointed Assistant Harbour-master at Hong-Kong in the Colonial Service. He subsequently became Harbour-master and Marine Magistrate. He was a member of the Legislative Council and the Imperial Defence Board. In 1914 August he was on leave in Java and narrowly escaped internment by the Dutch Authorities. Shortly afterwards he was appointed Marshall of the Prize Court at Hong-Kong.

In 1915 April he volunteered for service at the age of fifty, and went to Le Havre as a Naval Transport Officer. He was later employed in organisation of various ports in Northern France. He was invalided home in 1917

September, but returned to duty in 1918 January and went to Genoa, where he remained until the Armistice.

Whilst in Hong-Kong Taylour devoted a large section of his time and energy to codifying the laws and regulations of the Merchant Shipping Act. He also compiled a Trade Directory of Hong-Kong. One of his minor acts, after greatly improving the lighthouse service in the waters of the Colony, was to establish a circulating library for the men in the isolated stations. During the latter part of his life he was a chairman of the Kensington branch of the Navy League, and served on the committees of several naval, political, and charitable societies.

In 1903 Captain Taylour married Harriet, daughter of Brigadier-General H. B. Osgood, U.S. Army, and widow of Major Paul Glendenin. He is survived by her and by three sons and one daughter. He died on 1936 September 3.

He bequeathed to the Society his $3\frac{1}{2}$-inch equatorial.

ROBERT RUMSEY WEBB was born on 1850 July 9. From Monmouth Grammar School he came to St. John's College, Cambridge, in 1868 as a Sizar. He was Senior and first Smith's Prizeman in 1872, and immediately obtained a Fellowship at St. John's. He was a College Lecturer from 1877 to 1911, and was also Lecturer in Mathematics at Emmanuel College from 1878 to 1893. He gave some excellent lectures for the second part of the Tripos on Elasticity. But the main work of his life was as coach for the Mathematical Tripos. He succeeded Dr. Routh as the most brilliant, and the most successful, mathematical coach of his day. His devotion to teaching was unflagging, and there was a time when he taught sixty hours a week. At an earlier period (1878 to 1889) he had published a few brief mathematical papers, and although his energies were subsequently absorbed in teaching, he was always keenly interested in the development of his subject. But his real memorial lies in the careers of his pupils, to whom he was always a kind, if somewhat rugged, friend.

The following anecdote will serve as an instance of his kindness. One of his pupils, who had not done particularly well in College Mays, went to Webb in distress, and explained how Mr. X had been somewhat severe on him. "Did X say that?" exclaimed Webb. "I examined him in his Tripos, and I will show you his papers if you like. But look here, you had better come to me this term at five o'clock on Mondays, Wednesdays, and Fridays for half an hour." To appreciate this one has to remember how many hours a week he was working.

There was always a little Attic salt in Webb's lectures to his pupils. No doubt the jokes were repeated to successive generations of undergraduates, but they retained their freshness. He was somewhat of a recluse, but always enjoyed visits from former pupils. He was fond of travel, and interested in painting and music. During the latter part of his life he went in for linguistic studies over a wide range. He died on 1936 July 29.

He was elected a Fellow of the Society on 1879 November 18.

JOHANNES FRANZ HARTMANN was born on 1845 January 11 and died at Göttingen on 1936 September 13. He entered into astronomical work as a computer at the Leipzig Observatory in 1891; in the following year he transferred to Kuffner's Observatory at Vienna, returning to Leipzig as chief assistant at the end of 1893. In 1896 he transferred to the Astrophysical Observatory at Potsdam. After thirteen years there, during which he became a Professor of Astronomy (1902) and made a secure position for himself in the astronomical world, he was appointed Professor of Astronomy and Director of the Göttingen Observatory. In 1921 he became Director of the Observatorio Astronómico Nacional at La Plata in the Argentine Republic. He remained there until 1934, when he retired and returned to Germany.

While at Leipzig he helped Hayn in securing observations for the A.G. Catalogue for the zone 10°–15° N., carrying out also miscellaneous pieces of work, such as magnitude observations of Nova Aurigæ 1892, observations of comets, occultations, etc. At Potsdam he soon showed his knowledge and skill in instrumental and optical technique, and the *Zeitschrift für Instrumentkunde* contains a number of valuable papers dealing with his photometer—using a wedge and a Lummer-Brodhun prism—the construction and adjustment of spectrographs, temperature controls for spectrographs, the application of zonal tests to astronomical objectives (the Hartmann test) and the design of camera objectives for spectrographs. A new and highly accurate method of measuring stellar radial velocities was described by Hartmann at the St. Louis meeting in 1904, and the spectro-comparator, by which these measures were effected, became a standard part of the equipment of many observatories. At the same time Hartmann was interested in the exact measurement of wave-lengths, and numerous papers appeared on the scale of Kirchhoff's solar spectrum, the revision of Rowland's scale for wave-lengths, standard wave-lengths, and the relations between Rowland's wave-lengths and the International system. He also developed the Hartmann-Cornu formula for the reduction of prismatic spectrograms, and wrote papers on the presence of spark lines in arc spectra.

At the same time he was an active observer, being an early worker in the field of stellar and nebular radial velocities, and of nova spectra. Nova Persei was examined by him in 1901 and again in 1907, when he first pointed out the evolution of a nova into a Wolf-Rayet star. In examining monochromatic images of nebulæ he noted the different distribution of the gases giving various spectral lines, and made the surmise (though on grounds that were not confirmed) that the nebular lines at 3727 A. were probably due to oxygen. One important discovery that he made was the presence of narrow fixed lines of calcium in the absorption spectrum of δ Orionis; these he attributed to an intervening cloud of calcium vapour. Other papers published by Hartmann at Potsdam include a study of applications of anomalous dispersion, double lines in flash spectra, and photographs of minor planets.

While at Göttingen his individual output of work seems to have slowed down perceptibly, only a few papers largely along the lines of earlier work being noted; but he broke new ground in the study of the spectrum of Comet Morehouse and of the absorption at the head of the Balmer

series in hydrogen stars. The exact measurement of time also attracted his attention.

At La Plata his main activity became connected with the observation of minor planets and with orbital problems. Special pieces of work were also carried out, such as a redetermination of the longitude of the observatory by wireless (revealing a previous error of $1^{s}\cdot08$), observations of Eros at the last close opposition, and spectral and magnitude observations of Nova Pictoris 1925. In connection with this star Hartmann wrote against the explanation in terms of collision, and he was one of the early workers who examined the growth of the star by relating velocity displacements of the absorption spectra to changes of magnitude. His last interest, which he carried back with him to Germany, was in the reform of the Gregorian calendar.

He was elected an Associate of the Society on 1908 June 12 along with Baillaud, Charlier, Frost and Hagen, all of whom he survived.

F. J. M. S.

FRIEDRICH KÜSTNER.—By the death of Friedrich Küstner the Society has lost one of its senior associates and gold medallists, and our science one of the diminishing band of meridian observers who have investigated the sources of systematic errors in the observations, devised means of eliminating them, and personally made observations of the highest accuracy.

Born on 1856 August 22 Küstner was introduced to practical astronomy as a student at Strassburg by Winnecke, who was long celebrated as a most distinguished teacher of that subject. For Winnecke astronomy was not merely a branch of mathematics. The students had to become acquainted with the instruments and to make series of observations with them. The instruments, it is true, were at first only portable ones or those constructed for the transit of Venus and set up temporarily at Strassburg, but good use was made of them. The observations were carefully reduced and published, and the success of Winnecke's methods is shown by a list of Küstner's fellow-students—Hartwig, Elkin, Ambronn and H. Struve.

From Strassburg Küstner went to the office of the *Berliner Jahrbuch* in 1879. There he was principally employed on the computation of the orbits of minor planets, but he soon availed himself of the opportunity of working at the Berlin Observatory. After a short time, however, he was selected by Auwers to go as first assistant in the expedition to observe the transit of Venus in 1882 at Punta Arenas, and on his return to Germany he went for a short time to the Hamburg Observatory.

In 1884 Küstner was appointed to the staff of the Berlin Observatory, and returned to some work he had done there previously on the determination of the constant of aberration by the observation of the zenith distances of stars by the Talcott method. An anomalous result was obtained; the constant of aberration came out as $20''\cdot31 \pm ''\cdot011$, which differs from the accepted value of $20''\cdot47$ by many times its probable error. A comparison of the observations made in 1884 May with those made a year later led Küstner definitely to the conclusion that the latitude had changed in the

interval by $''\cdot204 \pm ''\cdot025$. This was the first series of observations which convincingly proved a change of latitude. The idea was by no means new. Euler had calculated that latitude might show a variation with a period of 305 days, and observations had been analysed to show this period, but with negative results. After Küstner had established the reality of a variation, series of observations were discussed by Chandler, who abandoned the period calculated by Euler. This analysis showed that there was a latitude variation with a period of fourteen months, and the controversy which arose was finally settled when Newcomb showed that Euler's calculations depended on the assumption that the earth was rigid and that the period would be longer for a non-rigid Earth. Küstner did not himself undertake further observations for latitude variation, but he devised a programme of observation for the determination of the constant of aberration by the Talcott method free from errors arising from latitude variation. This involved the observation of Talcott pairs in different right ascensions so that evening and morning observations could be made involving different displacements due to aberration, but the same displacement due to latitude variation. By continuing the observations over a year, errors in the star places could be determined and eliminated.

Küstner was next engaged in the observation of selected lists of stars with the meridian circle at Berlin, including fundamental stars, proper motion stars, comparison stars for heliometer observations, etc. That these observations were of unusual accuracy was shown by Auwers in *Cape Annals*, vol. vii, part ii, p. 702, where the positions of the comparison stars for heliometer observations are discussed. For a star observed five times by Küstner the mean errors were $\pm\,^{s}\cdot012$ and $\pm\,''\cdot19$, indicating that one observation by Küstner in R.A. had a weight 4·6 times that of an average observer, while one in Dec. had a weight 3 times that of an average observer.

In 1891 Küstner succeeded Schönfeld as Professor of Astronomy at Bonn, and Director of the observatory. For two years he was occupied with reorganisation of the equipment of the observatory, and by 1893 he was ready to start observing with a new 6-inch Repsold meridian circle. The catalogue of 10,663 stars between the equator and declination $+\,51^{\circ}$ which he made from his own observations with this instrument is one of the most accurate and useful that has ever been made, and some account of the origin of the programme and method of observation must be given.

In 1865 under the auspices of the *Astronomische Gesellschaft* a great international scheme for the determination of the positions of all stars in the northern hemisphere down to the ninth magnitude was undertaken. The observations were carried out at a number of co-operating observatories, each undertaking a zone of 3° or more. All the observations were reduced both in R.A. and Dec. by the positions of certain stars used as fundamentals and for which positions and proper motions were reduced by Auwers from a combination of modern observations with his own reduction of Bradley's observations. By 1890 it was clear that the observations made at the different observatories were neither in agreement with the fundamental catalogue nor homogeneous from one zone to another. When the work was under-

taken it was not fully realised that a magnitude equation existed in both co-ordinates and that it differed not only from observer to observer, but also for the same observer at different times. Küstner undertook a series of observations for the determination of the corrections necessary for the A.G. Catalogues. His plan was to select a number of stars distributed as uniformly as possible over the sky and determine their positions as free as possible from systematic error. To get rid of the troublesome error depending on magnitude he resolved on the plan of cutting down the brightness of the brighter stars to approximate equality with the fainter ones. The heroism of this plan can only be appreciated by those who have made regular observations of faint stars under poor climatic conditions. The standard magnitude to which stars were reduced by means of screens over the object-glass was 8·5, the reduction of the three screens used being carefully determined as 2·0, 4·2 and 6·4 magnitudes. The magnitude correction for outstanding residual differences in brightness was determined by the use of different screens on the same star, and the magnitudes of all the stars were carefully determined in the system of the Potsdam Photometric *Durchmusterung*. To give as great a uniformity as possible to the scheme, the observations were carried out by a single observer—Küstner—with an assistant to read the microscopes, in the shortest possible time. The bulk of the 25,469 observations was secured in the years 1894 to 1899. The plan was to observe each star once circle east and once circle west, but the above figures show that the actual average number of observations for each star was 2·4. The probable error varied slightly from zone to zone, but may be put as $\pm$ 0″·30 in each co-ordinate for a single observation, except that for stars fainter than 9·5 it rose to $\pm$ 0″·34 in R.A. The probable error of the magnitudes of the stars as determined by Küstner was $\pm$ $0^{m}$·095. The magnitude correction of the fundamental stars was determined at the same time.

At the time Küstner was completing his determination of the errors of the A.G. Zone Catalogues a similar problem arose in connection with the corrections required by the *étoiles de repère* used in the reduction of the plates of the Astrographic Catalogue. For the determination of these corrections Küstner made a selection of 6163 stars known as *étoiles intermediaires*. These stars were distributed nearly uniformly over the northern hemisphere, except that the density rose from about 1 to each 4 square degrees near the equator to 1 to each 2 square degrees at the pole. The magnitude of more than half these stars lies between 8·0 and 9·0 on the B.D. scale, but one in six are fainter than this and were intended for the determination of the magnitude error of faint stars, which are rather numerous amongst the *étoiles de repère* and for which the magnitude errors are liable to be large. As all the intermediary stars had already been observed for the A.G. Catalogue or Küstner's Catalogue, or both, it should be possible to get accurate proper motions within a reasonable time. Since the list was prepared these stars have been fairly well observed at several observatories (including Bonn), but not so extensively as was intended. This has probably been due, in some measure at least, to the introduction of the

self-registering micrometer, which largely eliminates the danger of magnitude error and makes the observation of very faint stars more difficult.

More recently when the *Astronomische Gesellschaft* decided to make a new determination of the position of all the stars in the zone catalogues, Küstner was naturally a member of the commission dealing with the subject. For the reduction of the photographs he selected the 13,750 reference stars to be observed with the meridian circles of a number of participating observatories. Also he had been engaged at the Bonn Observatory on the determination of the positions of stars in clusters by means of photography, so that he was in a position to advise on the best type of lenses to be used.

It is unnecessary here to go into detail on all the work done by Küstner as professor at the university and director of the observatory at Bonn. Naturally much of his time was taken up in official duties, and little was left to enable him to carry on his own researches. He gave much time to a revision of the Bonn *Durchmusterung*, examining the original records or making observations in the sky when errors were found in the B.D. As already mentioned, during Küstner's directorship the observatory carried on regular work on star clusters, and several years after his retirement, in 1931, he completed a publication on the globular clusters M12 and M5.

Küstner originated and successfully carried on spectroscopic observations at Bonn. With a three-prism spectrograph attached to the 30-cm. photographic telescope he determined radial velocities. From a series of 18 spectrograms of Arcturus made in 1904 and 1905, near the epochs of maximum displacement due to the Earth's orbital motion, he determined the linear velocity of the Earth in its orbit in terms of the velocity of light, and then deduced the solar parallax of $8''{\cdot}844 \pm ''{\cdot}017$, using the known values of the velocity of light, the length of the year and the radius of the Earth. This was the first practical determination of the solar parallax from the radial velocities of stars observed at different times of the year. The radial velocities of 99 stars were published by Küstner in *Ap. J.* (**27**, 301, 1908), and a later list of 227 stars in *A.N.* (**198**, 409, 1914). A discussion of the spectrum of Nova Geminorum 2 was given in *A.N.* (**194**, 369, 1913).

These references indicate the wide scope of Küstner's work. Although well versed in the theoretical branches of our science, he was quick to realise new possible lines of investigation, and the record he leaves is essentially that of a practical astronomer. In some ways it is interesting to compare him with Auwers, twenty years his senior, who worked much in the same field. Although Auwers in his earlier years was himself an observer—he was responsible for one of the A.G. zones—his great contribution to astronomy was the discussion of observations, especially Bradley's, with the greatest refinement. He did what was possible to improve the results to be obtained from observations. Küstner's great work was to make better observations. True progress in meridian astronomy results from a combination of the best possible reduction of the old observations and the most accurate new observations, consequently the work of Auwers and Küstner is complementary.

In his address on the award of the Gold Medal of the Society to Küstner, the president, Sir David Gill, used these words, "No true astronomer can follow Küstner's life without realising the sterling character of the man and his work. Splendidly equipped by nature for the pursuit of practical astronomy, drawn to that pursuit by his love of it, trained in the great school of his revered master, Winnecke, and devoting himself heart and soul to his pursuits, with constant thought and steady endeavour, he has contributed in a remarkable degree to laying strong and deep the foundations of that science to which he has devoted his life."

After his retirement from the directorship of the Bonn Observatory Küstner lived quietly in the devoted care of a daughter at Mehlem bei Bonn, revered by astronomers not only in Germany but throughout the world. Many honours were conferred upon him, amongst which we may mention the Bradley Medal of the Prussian Academy of Sciences, created in honour of Auwers's work. During the meeting of the International Astronomical Union at Leiden in 1928 an honorary degree was conferred upon him. He died on 1936 October 15, soon after completing his eightieth year.

He was elected an associate of the Society on 1899 November 10, and awarded the Gold Medal in 1910.

J. J.

PAUL HENRI STROOBANT showed an early interest in astronomy, his first paper being published by the Royal Academy of Belgium whilst he was at school. After having obtained his degree of doctor in mathematics and physics, he went to Paris in 1890 to take a course at the Sorbonne and to work for a time at the Paris Observatory. On his return to Belgium he was appointed an assistant astronomer at the Royal Observatory, Uccle. There he remained for the remainder of his astronomical career, becoming assistant director in 1918 and director, in succession to M. Lecointe, in 1925. He remained director until his retirement, only a few weeks prior to his death on 1936 July 15, at the age of sixty-eight years.

During his directorship the observatory was entirely re-equipped with new and modern instruments. These include an elaborate Ascania meridian circle of 19 cm. aperture ; a Cooke-Zeiss equatorial of 45 cm. aperture and 7 m. focal length, with micrometer ; a double Zeiss astrograph, each telescope having quadruplet lenses of 40 cm. aperture and 2 m. focal length, covering a field of 72 square degrees ; a Zeiss astrographic triplet of 30 cm. aperture and 1·5 m. focal length, covering a field of 81 square degrees ; a 7° objective prism ; a Zeiss reflector of 100 cm. aperture, equipped with two spectrographs ; also comparators and measuring machines. The new equipment was open to inspection on the occasion of the centenary celebrations of the observatory, in 1935 May, which were honoured by the presence of King Leopold and attended by many foreign delegates.

Professor Stroobant's astronomical work was very varied and touched on many different branches of astronomy. He was particularly interested in the minor planets, and made several researches on their distribution, number and

total mass. In the re-equipment of the Uccle Observatory care was taken to include instruments specially suitable for the discovery of minor planets. Amongst the many discoveries of new asteroids, made by M. Delporte, are two that are of particular interest because of their close approach to the Earth. After the discovery of Pluto, the planet was detected on one of the plates taken at Uccle, three years previous to the discovery, in connection with the search for minor planets.

The observation of meteors was another branch of astronomy in which Professor Stroobant was interested. In order to encourage the observation of meteors by amateur astronomers, he drew up for their guidance clear and detailed instructions in the methods of observation.

He made statistical investigations on the proper-motions and radial velocities of stars, and was the first to establish that the apex of the solar motion and the velocity of the Sun with respect to the near stars vary in a systematic manner with the spectral type of the stars.

Amongst other subjects that he discussed were the personal equation in the observations of star transits ; dynamical problems connected with planets and their satellites, and in particular the system of Saturn ; the motions of the helium stars ; the size of the local cluster of stars and the position of the Sun in the cluster ; and various problems in chronology.

Professor Stroobant took an active part at the meetings of the International Astronomical Union, and was President of the Commission on Bibliography. A volume entitled *Les Observatoires Astronomiques et les Astronomes*, compiled in 1907 by him, in collaboration with some of the staff at Uccle, is a valuable reference work. A revised edition was published in 1931 under the auspices of the International Astronomical Union. He was the author of a clear and concise text-book, *Précis d'Astronomie pratique*, based on the courses that he gave as Professor in the University of Brussels. He also published year by year, in the *Annuaire de l'Observatoire Royal de Belgique*, excellent reviews of the recent progress of astronomy.

Professor Stroobant was a Correspondent of the Paris Academy of Sciences, of the Bureau of Longitudes and of the Institut de Coïmbra. He was awarded the Lalande Prize of the Academy of Sciences in 1921. Shortly before his death he had been made Commander of the Legion of Honour. He was elected an Associate on 1930 June 13.

## PROCEEDINGS OF OBSERVATORIES

The following reports of the proceedings of observatories during the past year have been received from the respective Directors, who are alone responsible for them.

### *Royal Observatory, Greenwich*
### (*Director, Dr. H. Spencer Jones, F.R.S., Astronomer Royal*)

*New Reversible Transit Circle.*—The erection of this instrument was begun by Messrs. Cooke, Troughton & Simms on February 4. After the erection had been completed it was found that further grinding of the pivots was necessary. This was carried out by the contractors *in situ*, the work being greatly facilitated by the use of a Krupp "Mikrotast" gauge which had recently been purchased by the observatory. With the aid of this instrument the figure of each pivot could be investigated to an accuracy of about a twentieth of a micron (equivalent to a hundredth of a second of arc) in a comparatively short time. Measurements with the gauge were performed subsequent to each grinding operation, and indicated the portions of the pivot on which further work was required. The figuring of the pivots was completed on July 2, and the maximum departure of each pivot from the circular form is now about one hundred thousandth part of an inch. This is a highly satisfactory result, which has been achieved by the use of the "Mikrotast" gauge combined with the skill of Messrs. Cooke, Troughton & Simms' representative (Mr. T. Dwyer).

From a provisional determination with the optical pivot-testing apparatus it appears that the pivot errors (*i.e.* the errors arising from the combined effect of the two pivots) are of the order of a tenth of a second of arc or less. It was found that to obtain reliable results with the pivot telescope it was necessary to perform the operations with the objective set successively in four positions 90° apart. This eliminates errors arising from tilt of the objective, and if such an elimination is not performed the resulting pivot errors are apt to be spurious.

Work on the determination of the division errors of the circles is in progress. The operations have, so far, been confined to the fixed circle, and the errors of the five-degree divisions have now been determined. The extreme range of these five-degree division errors is 0·22 of a second of arc.

Preliminary observations are being made with the instrument. A satisfactory feature is its stability as shown by zenith distance observations of the same stars over a period of two months. The motor-driven micrometer works very well, but certain portions of the transmission gear are

objectionably noisy. It is hoped to remedy this. The three-pen chronograph, after the substitution of the original pens by syphon tubes, gives every satisfaction.

*Airy Transit Circle.*—The total number of transits observed during the year was 7964, including 118 of the Sun and 85 of the Moon. The observation of stars in the zone 0° to +24° declination, commenced in 1931, is approaching completion. Efforts are being made to obtain a minimum of 5 observations to each star.

*Cookson Floating Zenith Telescope.*—The number of plates taken for the determination of the variation of latitude were :—

| | | |
|---|---|---|
| January—18 | May—35 | September—12 |
| February—30 | June—5 | October—25 |
| March—23 | July—6 | November—14 |
| April—28 | August—29 | December—15 |

In addition to these, eight plates were taken for the determination of scale.

The telescope was dismantled on 1936 June 8. It has been re-erected in the Christie Enclosure, close to the Reversible Transit Circle.

On its re-erection the new programme, indicated in last year's report, was commenced. The number of stars per group has been increased, being now 6 or 7 pairs per group. 24 groups, each extending over about one hour in right ascension, have been selected, and three groups, centred round midnight, are observed throughout the year.

A definitive discussion of the observations, made during the 25 years in which the instrument has been in use at Greenwich, is now in progress. The observations have been used to derive improved mean places and proper-motions for each star-pair, the general system of the proper-motions deduced from the discussion of meridian observations being retained. It is found that the component, in the Greenwich meridian, of the secular motion of the Pole has never amounted, during these 25 years, to more than a few hundredths of a second of arc. The effects of direction and strength of wind on the observed latitudes is being investigated, and the influence of the wind on the latitude values for each period of observation, and on the derived group corrections, has been determined. It is already apparent, from the use of approximate wind corrections, that an appreciable smoothing of the observations results from their application. After correcting each plate residual for the wind terms, it is intended to make an investigation of the constant of nutation and of the lunar tidal effect on the variation of latitude.

Preliminary values for 1935·0–1936·4 were published in the Supplementary Number of the *Monthly Notices*, 1936 October.

*28-inch Refractor.*—A new programme was commenced in May with a working catalogue containing pairs, with a separation of less than 5″, which appear to show orbital motion. In addition, a number of Espin and Jonckheere stars in need of a second or third observation to establish motion and some easier pairs for observation on nights of indifferent seeing are included.

The number of observations made during the year is 505, distributed as follows :—

| | | | | |
|---|---|---|---|---|
| Separation ... | $> 2''.0$ | $2''.0 - 1''.0$ | $1''.0 - 0''.5$ | $< 0''.5$ |
| No. of obs. ... | 143 | 231 | 126 | 5 |

Of these, all but nineteen were made since May 1.

The seeing throughout the year has been below the average except for a brief spell during August. The practice of estimating the seeing on a scale of 5 has been adopted. Three observers have taken part in the new programme. An examination of 181 observations of 46 pairs revealed no personal equation greater than $0''.05$ in measurement of separation. A wooden cap for the 28-inch object-glass equipped with adjustable slits has been used to examine the conditions under which it would be possible to use an interferometer. Preliminary investigations show that the diffraction fringes are only seen when the seeing is 3 or better on a scale of 5. A comparison image micrometer which is a modification of that designed and used by Mr. F. J. Hargreaves is under construction. It is hoped to mount this instrument on the 28-inch telescope shortly.

The orbit of $\Sigma$ 2026 was computed by Dr. Woolley and Mr. Symms, using differential methods developed at the Union Observatory, Johannesburg. The period was found to be 680 years, the eccentricity 0·86, the semi-axis major $3''.04$ and the inclination $49°.4$.

*26-inch Refractor.*—The number of plates taken suitable for the determination of stellar parallaxes was 987. 694 plates were measured and 21 parallaxes completed. The parallaxes of 25 stars were published in the *Monthly Notices* for November. 42 plates were taken through the glass for the determination of proper motions of parallax stars for which there is an interval of 10 years or more since the first photograph. 10 of these plates were measured in both R.A. and Dec. The probable error of the proper motions so determined is about $\pm''.003$.

The projection method of measuring photographs suggested and put into practice by Prof. Schlesinger has recently been applied to the micrometer for measuring stellar parallax photographs. The light from a small 50-watt filament lamp is condensed by means of a lens into a small spot on the plate, passing thence into the microscope objective. Using the eyepiece as enlarging lens and with a small reflector above it, a magnified picture of the star image and micrometer wire system is projected on a screen coated with calcium carbonate or magnesium carbonate. This screen is adjusted to the measurer's most comfortable reading distance and measurement is performed with both eyes as in reading. The micrometer and measurer are shielded from extraneous light. The results show that there is no loss in accuracy of measurement, whilst the fatigue consequent on eyestrain is much reduced.

Experience since the reconstruction of the 26-inch mentioned in the last report amply justifies the alterations. Under normal conditions work is never interrupted through dewing of the object-glass, and its more protected

condition produces a much more constant focus throughout the varying temperature of the night.

The synchronous motor drive has proved most satisfactory. Less work falls on the Grubb controls than was the case with the weight-driven clock. As regards the steadiness of the frequency of the electric supply, the maximum departure of the motor from true rate is about one-half of 1 per cent., and the departure is usually less than one-fifth of 1 per cent.

*Yapp 36-inch Reflector.*—In continuation of the programme of colour temperature work using the slitless spectrograph, 271 comparisons of 90 stars of spectral type O to Go with standard stars have been secured. Rather more than half of the plates have been measured. 8 plates were exposed on Nova Lacertæ and 1 on Nova Aquilæ.

A paper giving the results for a selection of the plates exposed on Nova Herculis has been published in the *Monthly Notices*; also a paper on "Time Effects in Spectrophotometry."

Ten plates have been secured to determine the quantity $\phi_0'$ (see *M.N.*, **96,** 832), which it is thought might have been affected by the aluminising of the small mirrors. This represents about half the number required to secure a satisfactory determination.

The construction, by Messrs. Adam Hilger Ltd., of the new Slit Spectrograph is approaching completion, and it is hoped that the instrument will shortly be delivered.

*Astrographic Equatorial.*—The following plates were taken during the year :—

(i) 64 plates on the minor planet Hebe, taken between January 1 and April 20. These, together with the plates taken in 1935, will yield corrections to the elements of the planet's orbit, and of the orbit of the Earth.
(ii) 3 plates of the planet Pluto obtained on 1936 March 18, 21 and 24.
(iii) 5 plates on Nova Lacertæ for photographic magnitude.
(iv) 1 plate on comet Peltier.

In addition, 32 plates have been taken by Mr. H. G. S. Barrett, for the purpose of completing the observations of the Potsdam astrographic zones $+32°$ and $+33°$, which were taken over by the Oxford University Observatory.

*Photoheliograph.*—The Sun was photographed on 293 days at Greenwich and on 336 days at the Cape. Up to November 30 three days are not represented by either series, but plates for these dates have been received from Kodaikanal.

For the year 1936 the mean daily area of sunspots, corrected for foreshortening, was approximately 1200 millionths of the Sun's visible hemisphere. The published values for the years 1933–35 are 88, 119 and 624. The usual summary of positions and areas of sunspots for the year 1935 was published in *Monthly Notices*, **97,** 76, 1936. Sunspot numbers have been supplied quarterly to Zürich for incorporation in the *Bulletin*. The

presence of large sunspots on the disk is reported to the Radio Research Station at Slough.

*Spectrohelioscope.*—Observations were made in *Hα* light on 151 days, and include (*a*) 364 radial velocity measures on dark and bright flocculi; (*b*) a search for bright eruptions, of which 66 were observed during the year; (*c*) photometric measures of prominences and flocculi made with the comparison lamp photometer (134 observations), and with the direct-wedge method (162 observations).

The largest recorded components of radial velocity were those associated with bright *Hα* eruptions near sunspots, viz. −210 km./sec. and +190 km./sec. on February 14 and −300 km./sec. on December 22. Bright eruptions of major extent have been reported while in progress to the Radio Research Station, Slough, for comparison with radio observations on the reflectivity of the ionospheric layers. From a preliminary comparison made at Greenwich of data (supplied by the Union Radio Scientifique Internationale) of rapid fadings of short-wave radio transmission and of bright solar eruptions (published in the Zürich *Bulletin* under the auspices of the I.A.U.), there appears to be some evidence for a close relationship between the two phenomena during the period 1935 July 1–1936 June 30. The relationship appears especially in the case of the larger and brighter solar eruptions, and would seem to imply a solar agency travelling approximately with the speed of light. The evidence has been strengthened by several other coincidences that have been observed after 1936 June 30.

The photometric measures made with the spectrohelioscope include 79 measures made with the lamp photometer on solar prominences about 2′ in height. The mean maximum intensity (*not* total intensity) of the non-eruptive prominences, as compared with that of the continuous spectrum at the centre of the disk, for a wave-length 10 A. from the centre of *Hα* is 9 per cent. (uncorrected). This is the same value as that obtained from similar observations during 1934–35 (see *Monthly Notices*, 96, 13, 1935). The intensities for the few eruptive prominences showing motion in the line of sight that were measured during 1936 ranged from 11 to 32 per cent. On days when conditions were favourable enough, 26 prominences were observed in *Hβ* as well as in *Hα*. The ratio of the maximum intensities of *Hβ*/*Hα* derived from these prominences is 0·35 as compared with 0·26, the value given by 22 prominences in 1934–35.

Photometric measures made on bright *Hα* eruptions show that the rise in intensity to a sharp maximum is usually very rapid, in about 5 to 7 minutes, the decline in brightness usually taking from 20 to 40 minutes. The maximum intensity of the 66 bright eruptions observed during the year exceeded that of the continuous spectrum 10 A. from the centre of *Hα* at a closely adjacent part of the disk on seven occasions.

*Clocks and Time Service.*—During the year observations for the determination of clock correction were made on 138 nights with the small reversible transit. The time service has been maintained as in previous years. New steel suspension springs were fitted on July 6 to the sidereal free pendulum

clock Shortt No. 11, and on October 24 to the mean time free pendulum clock Shortt No. 49.

A notable event during the year was the delivery of a new free pendulum sidereal clock. This clock, Shortt No. 40, is the gift of Mr. H. R. Fry. The installation includes an improved slave clock and provision for taking time directly off the free pendulum by a photo-electric method. The clock movement is mounted in an air-tight case, constructed by Messrs. Metropolitan Vickers Ltd., which is fitted with windows of optically worked glass, so as to allow the passage of the light beam employed to energise the photo-electric cell. The photo-electric apparatus itself is at present in course of construction in the observatory workshop.

The improved slave was specially constructed by the Synchronome Co. Ltd. All its essential bearings have been jewelled, and consequently a much lighter impulse lever has been used. Another improvement is the use of a pivoted synchronising arm in place of the usual feather spring.

The new clock promises to be a valuable addition to the equipment of the observatory, and the appreciation of the Lords Commissioners of the Admiralty has been conveyed to Mr. Fry.

On April 18 a modification was introduced into the sidereal clock circuits, transformers and unbiased relays replacing the biased relays previously used. The alteration reduces the possibility of errors arising from relay lag.

A new radio receiver, constructed by Messrs. Haynes Radio Ltd. in co-operation with the Radio Department of the National Physical Laboratory, has recently been acquired. It has not yet been brought into regular use.

*Observations of Eros.*—The measurement of the several series of plates taken in connection with the 1930–31 opposition, whose measurement was undertaken at Greenwich, has been completed. 243 plates were measured during the year. The total number of plates measured in the course of this work has been 1226.

The reductions are proceeding. As regards the primary reference stars (Dr. Kopff's list), the residuals of the star places as determined at Greenwich, Cape, Bergedorf, Leipzig and Lick have been ledgered and the weighted means taken. It is proposed to publish these results in the form of a catalogue, and the copy for press will shortly be prepared.

The places of the secondary reference stars (required for the reduction of Eros plates obtained with long-focus instruments) have been reduced and a comparison made of the determinations at the five observatories mentioned above. It has been found necessary to apply a correction of $+0''{\cdot}15$ in declination to the Bergedorf and Lick positions. The catalogue for these stars is nearly completed for the stars south of the Equator, and for the northern stars the places have been partly ledgered.

As regards the Eros plates the reductions are proceeding, using provisional places for the reference stars.

Mr. H. G. S. Barrett is assisting in the Eros work. His services have been lent to the observatory by the Radcliffe Trustees and are much appreciated.

*Measurement of Total Line Intensities in the Solar Spectrum.*—The train

of four prisms which, as was mentioned in the last report, had been ordered from Messrs. Ross Ltd., has been delivered. An optical bench has been purchased. It is hoped to proceed with the work during the coming summer.

*Air Pollution.*—A daily estimation of pollution of the air, both by solid and gaseous matter, has been maintained. The monthly means show that average pollution by sulphur dioxide (which is considered to be the major constituent of gaseous pollution) ranged from ·023 parts in a million in July to ·104 p.p.m. in November. On the worst day of the year (November 25) it reached ·262 p.p.m.

The amount of pollution present is very closely related to the direction of the wind. Wind from a northerly direction brings with it the products of combustion not only from the industrial sector of London but also from a large residential area. On calm days there is, of course, an accumulation of local pollution. As an outstanding example of the effect of the direction of wind, January 1935 may be compared with January 1936. The wind came from between north-east and north-west for 42 per cent. of the month in 1935, and the mean pollution was ·146 parts per million ; in January 1936 the figures were 5 per cent. and ·060 p.p.m. respectively.

Comparing the two years as a whole, there is an apparent slight increase in gaseous pollution, namely from ·052 to ·058 parts per million ; but there was also a corresponding increase both in the proportion of northerly wind and in calm periods. The proportion of northerly wind increased from 15·0 per cent. to 16·8 per cent., and of calm periods from 15·0 per cent. to 18·8 per cent.

Pollution by suspended matter has shown considerable improvement, particularly during the winter months. This may be a reflection of the relative scarcity of smoke fogs during 1936.

*Printing.*—The volume and separate parts of *Greenwich Observations* for 1934 have been distributed. The final proofs of the major portion of the *Observations* for 1935 have been passed for press.

*Miscellaneous.*—Dr. P. Slavénas of the Kaunas Observatory, Lithuania, studied the work of the observatory for a week in July.

M. Vandekerkhove, of the Royal Observatory of Belgium, worked at the observatory from November 20 to the end of the year. He was engaged in a study of the methods employed in the Colour Temperature programme.

## *Royal Observatory, Edinburgh*

(*Director, Professor R. A. Sampson, F.R.S., Astronomer Royal for Scotland*)

The regular work has continued without change of plan. The Great Reflector in the East Dome is engaged in collecting spectra, and the camera in the West Dome in taking plates which are afterwards examined for variables in the blink microscope. The chronographic system is employed in time-service. Some additional negatives were lent to Professor Stratton, at Cambridge, in consequence of his being made President of the Sub-commission on Novæ of the International Astronomical Union. These

were taken with the Reflector in the East Dome, with a slit spectroscope, and include a comparison spectrum.

In connection with the eclipse of the Sun on June 19, the 4-inch direct vision prism was lent to the Joint Permanent Eclipse Committee, and has now been safely returned.

A meeting of the International Union of Geodesy and Geophysics was held here in September. Though not expressly a meeting of astronomers, in connection with it numerous distinguished astronomers visited the observatory, being interested specially in the seismograph and related questions, and in the chronographic system. A paper by Professor Sampson was presented to the meeting, on the Arc Equation of Clocks, which has been printed in the *Proceedings of the Royal Society of Edinburgh* (vol. lvii, 1937, Part I, No. 4).

Some mention was made in the last report that the case of Shortt No. 4 was leaking. The leak proved amenable to ordinary tightening and greasing arrangements, and the clock is now going satisfactorily.

The Great Mirror was sent in May to Metropolitan Vickers, Ltd., to be aluminized. It was the first large mirror to be aluminized by any British firm. It suffered the fate of a pioneer, for it was not returned till after five months. No blame attaches to the firm in connection with this delay. It is understood that they were held up by ordinary commercial work, and some delay resulted in making and installing suitable appliances for handling a mirror of five hundredweight. No doubt when these arrangements are made they will proceed very much more rapidly. Since its return it has been examined for any change of figure, and though critical decision depends upon the seeing, the figure is certainly good and probably unimpaired.

Arrangements have been made to place a driving clock controlled by a synchronous motor in the Garden Dome, including change wheels to make the star trail if necessary. It was felt that the old arrangement, of a clock regulated by a one-second pendulum, was objectionable. The appliance has only just been fitted and, though it is not expected that it will go wrong, no final decision can be made.

A very long debate with H.M. Treasury, which was complicated with matters relating to other people, has resulted in no publications from this observatory being issued in the tenure of the present Director. It is hoped that this matter is now drawing to a satisfactory conclusion.

The Crawford Library is of great and increasing value to this observatory. Gifts from other observatories, and the provision of H.M. Stationery Office, supply all ordinary defects, but there are still some deficiencies in books which are out of print, and which are discoverable, though they have to be carefully looked for. More attention has been paid to these gaps.

The oldest member of the servants, Mr. David Graham, porter and cleaner, who had served for thirty-one years, died in December last.

*Royal Observatory, Cape of Good Hope*
*(Director, Dr. J. Jackson, H.M. Astronomer)*

*Reversible Transit-Circle.*—The observation of stars between the equator and declination $-30°$ commenced in 1932 was completed in March. The working list contained 7415 stars, including all those down to magnitude 7·5 except stars observed in the First Cape Catalogue for 1925. Nearly all stars have been observed four times, twice on each clamp.

During the months April to September a special programme involving observations near sunrise and sunset was carried out. The stars observed included clock stars and other fundamental stars near the equator taken from F.K.3, and all almanac stars within 20° of the South Pole. Special attention was given to the observation of the latter stars at consecutive transits above and below pole. These observations will give the first fundamental determination of the positions of polar stars since 1918. The observation of the equatorial stars will give a strong determination of the residual errors of the star places depending on the right ascension. Except for a few stars very close to the pole, all the polar stars were observed with the motor-driven wire in the same way as the equatorial stars. It is intended to use stars between declination $-70°$ and $-80°$ for azimuth determinations in future. The total number of observations in this programme was 5370, more than a third being of polar stars.

In October the observation of an extensive programme of fundamental stars was commenced. The working list includes all Boss and Backlund-Hough stars south of declination $+35°$, and contains in all 5373 stars. It is intended to observe all stars at least ten times.

The total number of transits observed in the year was 10,186, including observations of the Sun on 165 days, Mercury on 71 days and Venus on 113 days. The exterior planets were observed two or three times a week during the usual evening hours of observation.

In the intervals between the catalogues the instrument was overhauled and repainted. The system of fixed wires was renewed, and the time of observation of equatorial stars increased from 5·5 to 13·1 seconds. For the last 18 years the instrument has been used in Position I. This was changed in September to Position II by the interchange of the object-glass and eye-end.

The copy for press of 8400 stars south of declination $-30°$ and 3267 zodiacal stars observed in the years 1925 to 1933 was completed except for the proper motions. Completion of the volume is being held up, as it is hoped to extract the proper motions of most of the stars from the new General Catalogue which is being prepared at Albany.

A discussion of the observations of the Sun, Mercury and Venus made in the years 1925–32 has given the following corrections to the R.A.'s of Boss's Catalogue: $-0^s.035 \pm 0.006$, $-0^s.032 \pm 0.010$, $-0^s.029 \pm 0.009$.

*Eight-inch Transit-Circle.*—The observation of reference stars for the zone $-35°$ to $-40°$ is nearly completed. During the year 3952 transits were observed.

These stars are observed for the reduction of photographs taken with the wide-angle lens. When the zone $-35°$ to $-40°$ is completed, the zone $-52°$ to $-56°$ will be undertaken. A working list is being prepared.

*Photographic Zone Observations.*—(*a*) Zone $-30°$ to $-35°$. Fifty-three plates were measured, completing the measurement to R.A. $18^h\ 30^m$. So far about 10,000 stars have been measured, each on two plates. The computation of the standard co-ordinates of the stars to be measured is complete to $18^h\ 54^m$ and checked to $18^h\ 30^m$.

(*b*) Zone $-35°$ to $-40°$. The photography of this zone was completed by taking 39 plates. All the plates have been taken within a year.

In addition four plates were taken of Comet Peltier (1936 *a*), four of Nova Sagittarii and two of star clusters.

The measuring machine was adapted for measurement of the star images by projection on a white matt surface.

*Cape Astrographic Zones* $-40°$ *to* $-52°$.—The volume containing the proper motions of the 20,843 stars of the Zone Catalogue for 1900 has been published. The copy for press of a further catalogue of 20,554 stars fainter than magnitude 9·0 on the C.P.D. scale has been completed as far as positions, precessions, secular variations, proper motions and photographic magnitudes are concerned. The spectral types as far as they are available from the Draper Catalogue have been entered. Arrangements have been made with Dr. Shapley to have the spectral types of as many stars as possible determined on the plates stored at the Harvard Observatory. The principal difficulty in carrying out this work has been the identification of the stars. For the first $2^h\ 40^m$ of R.A. where the stars are relatively scarce, the stars were identified from the R.A. and declination given in the copy for press, but this method proved too laborious. For the rest of the work photographic prints have been made from the chart plates for the odd degrees of declination, and the stars for which spectral types are required have been marked on these prints. The prints with the spectral types marked have been received to 6 hours of R.A. Out of 2005 stars in this section of the catalogue the spectral types of 1447 are now available as compared with 476 in the Draper Catalogue. In the rich galactic regions about 8 hours of R.A. Harvard Observatory possesses specially good plates, so that it should be able to make a very valuable contribution to this catalogue.

*Astrographic Telescope.*—Five plates were taken of Comet Peltier, three of Nova Aquilæ (1936, 1), three of Nova Sagittarii and three of star clusters. Five plates were exposed to test the focus and adjustment, and four to test the speed of photographic plates.

*Victoria Telescope.*—The instrument was in use on 260 nights. 3143 plates were secured for the determination of stellar parallax, and 142 plates for the determination of proper motion in declination of stars for which the parallax and proper motion in right ascension have already been published.

1758 plates were measured for parallax and 363 for proper motion in declination. 136 plates were rejected as unsuitable for measurement, and there remain on hand for measurement 2224 plates.

The parallaxes of 100 stars were published in the *Monthly Notices* for

November. This brings the total since 1926 to 750. The parallaxes of a further 39 stars have been determined. For four stars the parallax exceeds 0″·100. Two of these are faint stars for which no other parallax has been published.

The copy for press of the details of the parallax determination for 202 stars is nearly completed. The proper motion in declination for all of these stars except five has now been determined, and this will be completed as soon as the necessary plates are available.

Eighteen plates of planetary nebulæ and 7 plates of star clusters were taken. These were mostly of long exposure. Four plates were taken of Comet Peltier (1936 *a*) soon after the time of closest approach of the comet to the Earth.

*Occultations.*—The following occultations of stars by the Moon were observed :—

| | | | | |
|---|---|---|---|---|
| Disappearances | at the | dark | limb | 44 |
| Reappearances | ,, | ,, | ,, | 27 |
| Disappearances | ,, | bright | ,, | 4 |
| Reappearance | ,, | ,, | ,, | 1 |
| | | | Total | 76 |

The results of the observations made in the years 1932–35 were published in the *Monthly Notices* for June.

*Photoheliograph.*—674 photographs of the Sun were taken on 336 days. For the determination of zero point of position angle 25 plates were taken with double images of the Sun and visual observations were made weekly. The original negatives to October 29 and the duplicates to December 4 have been sent to Greenwich for measurement and preservation.

*Photometric Telescope.*—The photographic and photovisual lenses of 35-inch focus covering a field about 15° in diameter have been mounted in the new building erected in 1935, and scales have been provided for the guiding telescope.

*Clocks and Time-Service.*—The performance of the standard sidereal clocks has been fairly satisfactory, although considerable trouble was experienced in the early part of the year through small leaks in the cases. These have now been remedied. Riefler 152 requires adjustment of the contacts inside the case, and has a persistent tendency to jump seconds at frequent intervals.

The standard mean time clocks have worked well throughout the year.

The emission and reception of time-signals has been continued as in the previous year.

*Cambridge Observatory*
(*Director, Sir A. S. Eddington, F.R.S.*)

The main observational work has been, as in recent years, photo-electric photometry of variable stars. The stars under observation are : $\beta$ Lyræ ; *b*, $\beta$ and $\phi$ Persei ; $\lambda$ Tauri ; $\rho$, $\gamma$ and 1H Cassiopeiæ ; Procyon ; $\zeta$ Geminorum ; $\delta$ Cephei ; *u* Herculis ; Boss 809 and 5579. It is now possible

to judge the effect of the changes recently made in the equipment, namely, substitution of a new photographic object-glass, aluminising the mirror at the elbow-joint of the telescope, and inserting in the electrometer a condenser calculated to give increased sensitivity. The combined result is a gain of a little more than two magnitudes.

A discussion of the colour temperature of Nova Herculis based on one of the plates taken with the Thorrowgood telescope has been published by Mr. E. G. Williams and Mr. Green (*M.N.*, **96,** 434).

An extensive statistical discussion of the radial velocities of 3700 stars for the determination of the solar motion and galactic rotation has been made by Dr. Smart and Mr. Green (*M.N.*, **96,** 471). Further papers on theoretical problems arising in connection with this investigation have been published by Dr. Smart.

The following research students have been working at the observatory: S. W. Shiveshwarkar, M. Krook, G. L. Clark, J. Fleming. Mr. Shiveshwarkar has published work on the dynamics of a stellar system, and Mr. Krook on the conditions necessary for high central density in a star (*M.N.*, **96,** 749, 761).

The Director has brought to a conclusion a theoretical research by which the cosmical constant is calculated in terms of other constants of nature whose value is known experimentally. The preliminary ideas from which the theory has been developed were first outlined in 1931 (*M.N.*, **92,** 3). The calculation, which is now believed to be definitive, gives a limiting speed of recession of the extra-galactic nebulæ of 432 km. per sec. per megaparsec. This makes the scale of nebular distances about 30 per cent. greater than that adopted by Hubble, and, for example, places the most distant nebular cluster observed spectroscopically 330 million light years away. The theory also gives the constant of gravitation as $6{\cdot}659 \pm {\cdot}0012$, which agrees better with the values of Boys and Braun than with recent determinations by Heyl. A general account of the principles of the calculation was given at the Harvard Tercentenary Conference, and will be published in the *American Journal of Mathematics*; the mathematical details are included in a book, *Relativity Theory of Protons and Electrons*, recently published.

The observatory will shortly lose the services of Dr. W. M. Smart, First Assistant and John Couch Adams Astronomer, who has been appointed Regius Professor of Astronomy in the University of Glasgow.

### *Solar Physics Observatory, Cambridge University*
### (*Director, Professor F. J. M. Stratton*)

Mr. C. P. Butler resigned from the staff at the end of September. He joined the staff of the South Kensington Observatory in 1899, and came to Cambridge in 1913, when the observatory was transferred there from London. He has been chiefly occupied while in Cambridge with the regular observations with the spectroheliograph and more lately also with

the spectrohelioscope. He also was a member of four eclipse expeditions, namely in 1905, 1914, 1927 and 1932. Mr. W. Moss, now First Senior Observer, has succeeded Mr. Butler in the solar work. Mr. E. G. Williams has joined the staff as First Junior Observer. Professor C. T. R. Wilson, associated with the observatory since 1913 as observer in Meteorological Physics and later as Jacksonian Professor, has now left Cambridge. During the absence of the Director and Assistant Director on an eclipse expedition to the Hokkaido, Dr. T. W. Wormell acted as Deputy Director. Assistance in the work of the observatory has been received during the year from Dr. C. W. Allen (solar research including eclipse observations), Major R. A. Bagnold (eclipse), Dr. A. Beer (novæ), Mr. M. Krook, Isaac Newton student (line photometry of stellar spectra), Major Noto (meteorology) and Mr. E. C. Shirley of the Radcliffe Observatory staff (nebular photography). Dr. J. C. Boyce of the Massachusetts Institute of Technology and Dr. J. M. Mohr of the Astronomical Institute, Prague, worked at the observatory for several weeks.

*Buildings and Instruments.*—A new hut has been erected for the wireless transmitter used by workers from the Cavendish laboratory for ionospheric research. The thermostatic control of the McClean-Littrow spectrograph has been extended to include the whole instrument and not merely the prism box; the 30° prism has also been refigured, and a new linkwork mounting for the prisms controlled by a motor has been added. It is now possible to keep an exposure going for 24 hours without shift in the lines, and the definition is much improved. A new cine-camera has been fitted to the spectrohelioscope for recording rapid changes of form in the markings and variations dependent on changes of wave-length.

*Solar Work.*—Spectroheliograms were secured in $K_{232}$ light of the disc on 88 days and of the limb on 77 days, in $H\alpha$ light of the disc on 17 days and of the limb on 15 days. Observations with the spectrohelioscope were made on 63 days.

The central intensities and equivalent widths of the Fraunhofer lines in the region 6000–6300 A. (including the special region selected by the I.A.U. for general comparison) have been measured by Dr. Allen (*M.N.*, **96**, 508) with the Rowland grating, as also the equivalent widths of lines in the region 6600–11,000 A. He finds that with proper corrections for instrumental distortion the narrow Fraunhofer lines are almost as deep as theory requires, a result fully confirmed by Dr. Redman using the McClean prismatic spectrograph. The latter finds in some preliminary work central intensities of the order of 1 *per cent.* or less not uncommon among the strong metallic lines observed on undisturbed parts of the Sun's disc (accurate measures on *Fe*I 4326 A. give a central intensity of 0·2 *per cent.*).

The results of the observations on the total radiation from sunspots and faculæ, using a thermocouple and galvanometer, have been published (*M.N.*, **96**, 159, 736). Real differences between the intensity of total radiation from the umbræ of different spots have been found. The total radiation emitted radially from a disturbed area, containing spots and surrounding faculæ, is definitely less than from an equal undisturbed area;

the energy emitted tangentially from the faculæ may be as much as 9 *per cent.* greater than that from the photosphere and the total emitted tangentially from a disturbed area may be in excess of that from an undisturbed area.

*Solar Eclipse.*—The Director, Dr. Redman, Major Bagnold and Dr. Allen went from the observatory to Kamishari in the Hokkaido to observe the total solar eclipse of 1936 June 19. They were joined by Dr. Royds, Director of the Kodaikanal Observatory, sent by the Government of India, and by Mr. A. D. Thackeray, Commonwealth Fund Fellow, and later by a party of observers for the eclipse itself. Unfortunately the sky clouded up and the Sun was totally obscured within a few seconds of the commencement of totality. Dr. Royds was able to carry out his programme on the wave-lengths of the Fraunhofer lines during the partial phase, save for the last plate before totality and the first ten minutes after totality. The first flash was also secured through thin clouds. The Japanese National Eclipse Committee and the authorities of the Hokkaido gave the greatest possible assistance to the expedition.

Mr. Williams accompanied the successful expedition to Omsk under Professor Carroll and secured plates of the infra-red region of the flash and coronal spectra.

*Stellar Work.*—With the Newall refractor 184 stellar spectrograms were secured on 127 nights: further spectra were secured from time to time with the Huggins refractor and the calcite slitless spectrograph on the Thorrowgood telescope. The principal stars observed have been Nova Herculis 1934, Nova Lacertæ 1936, Nova Aquilæ 1936 (No. 1), P Cygni, $\zeta$ Aurigæ and $\gamma$ Cassiopeiæ. The varying intensities of the hydrogen lines are under examination in the case of the last-named star. Work has also commenced on a programme of selected stars to test Professor Carroll's method of measuring stellar rotation.

With the 3-foot reflector 77 plates (68 on nebulæ and 9 on standard stars) were obtained on 41 nights. Magnitude data for six extra-galactic nebulæ have been published (*M.N.*, **96**, 538). The distribution of luminosity along the axis of the Andromeda nebula, M 31, has been measured over a range of surface brightness of 50,000 to 1. The result shows a wide divergence from the result given by Professor Shapley in his George Darwin lecture (*M.N.*, **94**, 805, 1934) that the low-density envelope of the nebula is nearly circular in outline.

Considerable progress has been made in the study of the spectroscopic material of Nova Herculis. Dr. Beer has published a study of the nebular stage (*M.N.*, **96**, 236), while the earliest phase has been examined by the Director (*Annals S.P.O., Cambridge*, **4**, part 4). Early investigations on Nova Aquilæ 1918 by Dr. E. S. Pearson and Nova Persei 1901 by the Director have also been published (*Annals S.P.O.*, **4**, parts 2 and 3). A photometric study of the intensities and contours of the emission bands and absorption lines of *H*, *Fe*II and *Mg*II of Nova Herculis during the earliest phase is in hand, also a spectrophotometric study of the forbidden lines of *O*I, *N*II. Preliminary work has been done by Dr. Beer on the spectra of Nova Lacertæ 1936 and Nova Aquilæ 1936, No. 1. Dr. Beer

is also continuing his work on spectroscopic binaries, paying special regard to the relation between the masses and the hydrogen content of the stars.

*Meteorological Physics.*—The reduction of the observations on the electric fields of thunder-clouds obtained with a capillary electrometer during the past ten years is almost complete and the results are being prepared for publication.

*Laboratory Work.*—The work on the spectrum of *Fe*II is now being prepared for publication. A number of the fainter lines have been traced to water-vapour.

A comparison of the laboratory intensities of multiplets of *Fe*I showed closer agreement between the arc and the Sun than between either of these and the calculated intensities.

*Durham University Observatory*
(*Observer, Mr. Frank Sargent*)

The observation of variable stars has been continued according to the programme.

The seismograms taken with the Milne-Shaw seismograph up to 1936 June 30 have been analysed and forwarded to Oxford for inclusion in the International Seismological Summary.

In accordance with the University of Durham Act, 1935, the control of the observatory will ultimately pass from the Council of the Durham Colleges to the Senate of the University. The transfer is expected to take place during the current year.

*Imperial College Observatory, S. Kensington*
(*Director, Assistant-Professor H. Dingle*)

The usual courses of instruction to students in astronomy and spectroscopy have been given. Laboratory research has been concerned mainly with the production and analysis of band spectra and applications of spectrum analysis to problems in medicine, but arrangements have been made to co-operate in the programme of observations of solar spectrum line profiles proposed by Commission 12 of the International Astronomical Union.

A grazing incidence vacuum grating spectrograph is under construction, the purchase of which has been made possible by a grant from the Government Grant Committee of the Royal Society and the gift of a grating by Professor Manne Siegbahn of Upsala.

The observatory has suffered a loss through the death of Dr. C. V. Jackson, whose interferometric measurements of wave-lengths have contributed materially to the establishment of accurate standards in this work.

*Liverpool Observatory and Tidal Institute*
*(Director, Professor J. Proudman, F.R.S.; Associate Director, Dr. A. T. Doodson, F.R.S.)*

Tidal predictions of high and low water have been made for seventy-three places, of hourly heights for one place and of times of slack water for three places. Tidal observations from twenty places (a total of fifteen years' record in all) have been analysed.

The new methods of analysis and prediction of tides, for use by seamen, which have been devised by Dr. Doodson and Commander Warburg, have now been published in *Admiralty Tide Tables*, Part III.

The particular research which has received most attention during the year has been the beginning of an intensive observational study of the structure of a tidal current. The work was carried out in collaboration with the Department of Oceanography of the University of Liverpool, and was made possible by substantial grants from the Government Grant Committee of the Royal Society. The observations were made during the month of August, about six sea-miles to the south of the Isle of Man.

The work on the dynamical theory of tides in oceans bounded by meridians, and on the collection of monthly and yearly mean values of sea-level observed at stations distributed over the world, have been continued.

The Roberts tide-predicting machine has been modified and extended, the number of constituents being increased from thirty to forty.

An invar pendulum has been fitted to the Lancaster clock which is used to insert time marks on the seismograph records.

The regular meteorological and seismological services and the daily firing of the time-gun have been continued.

*University of London Observatory, Mill Hill, and University College Observatory*
*(Director, Prof. L. N. G. Filon, C.B.E., F.R.S.; Wilson Observer, Mr. C. C. L. Gregory, M.A.)*

(*a*) Observations were made on 171 days and on 150 nights. 56 plates were obtained during the year, 2 of 80 minutes exposure on Wilson Regions for Proper Motions, 15 radial velocity spectrograms, 4 being of $\gamma$ Cassiopeiæ. The remainder were of Comet Peltier and various other objects. An undergraduate student in astronomy at University College took 9 plates with the astro-camera attached to the Fry telescope for practice in measurement and reduction.

The Sun was observed for the positions of spots on 77 days.

Visual observations with the Fry telescope were made on 94 nights, including 60 observations of star positions which have been used for testing suspected small variations in the pier; also a number of observations of the magnitude of Novæ and of the positions of comets have been made.

Advantage has been taken of the Littrow spectrograph by two students reading for the B.Sc. degree. 28 observations of occultations were obtained, which have now been computed. Miss White, a past research student, now on the staff of Bedford College, has measured the Proper Motion plates for two more of the Wilson Regions, the results of which have been incorporated in a paper which she has submitted to the Society for publication. She has now started measuring two more Regions, leaving only a further two for the completion of this work. The Wilson Observer has started on the measurement of the radial velocity plates, but lack of time makes the progress slow.

(*b*) *Experimental Transitgraph.*—No more plates have been taken with this instrument during the year. Early in the year it was loaned to Dr. Souttar at his request, in order that he might try some additions and alterations to the instrument.

(*c*) *Visitors.*—The number of visitors during the year was 116.

(*d*) *Gifts to the Observatory.*—There have been a number of valuable gifts to the observatory, including that of a wireless amplifier and electrically driven chronograph by Mr. Fry for the automatic reception of wireless time-signals. This has operated very satisfactorily for the past two months and has replaced the wireless set presented to the observatory by Mr. C. V. C. Herbert when it was first opened. Mr. Fry also presented the observatory with a 5-inch visual objective and tube by Cooke.

(*e*) *Observatory Bulletin.*—It is hoped to publish a series of Observatory Bulletins, produced by the Fordigraph process.

(*f*) *The Radcliffe Telescope.*—A protective coat of red-lead paint has been given to a number of the metal parts of the dome, etc., of this instrument which are still exposed to the weather in the observatory garden pending the re-erection of this instrument. Also the observatory mechanic has continued the work of cleaning and renovating such parts of the instrument as require this.

Negotiations were started during the summer to rent an additional piece of land behind the observatory for its erection, but were temporarily suspended owing to an increase in the road lighting, the effects of which could not be predicted. It has now been found that the general increase of illumination due to the street lighting is not serious, and it is hoped that, if and when the observatory has been screened from the direct lighting, negotiations may be resumed.

(*g*) *Voluntary Assistance.*—As in former years, considerable voluntary service to the observatory has been rendered by Mr. Frank Robbins, especially in connection with the clocks, observations of occultations and computations; also by Miss White in measuring plates.

As was pointed out in the last two annual reports, the chief requirement of the observatory at present is an addition to the staff.

(*h*) *University College Observatory.*—The work, which is mainly instructional, has been carried on as in previous years.

*University Observatory, Oxford*
*(Director, Professor H. H. Plaskett)*

*Staff.*—The observatory has suffered serious losses during the year in the death of Dr. J. K. Fotheringham and Mr. F. A. Bellamy. The former served as Assistant and Honorary Assistant from 1918 until his death, while the latter was Chief Assistant for nearly the whole of his 44 years' service.

*Equipment.*—A gift of £100 from Merton College, coupled with permission from the University Chest to use money otherwise earmarked for the salary of the Chief Assistant, has made it possible to commence work on the slit and plate-holder breech of the solar spectroscope. The design has been altered in some respects and work on the castings is now in progress. Hartmann tests on α Aquilæ with the solar telescope having apparently revealed astigmatism with a path difference of $\lambda/2$ for small angles of inclination of the cœlostat and secondary mirror, it is expected that these mirrors will shortly be taken back by the makers for re-examination and refiguring.

*Astrophysics.*—The observational part of the surface brightness determination of the Sun having been completed in previous years, work during the year under review has been confined to measures of the transmission of the wedge and screens used in equalizing the fluxes from the Sun and the standard lamps. It is hoped shortly to complete this investigation, and thus establish or disprove the existence of the isothermal region in the Sun found from studies of solar granulation (*M.N.*, **96**, 402). A spectrophotometric investigation of the continuous spectra emitted by planetary nebulæ was completed by Mr. T. L. Page during the year (*M.N.*, **96**, 604), as well as a short study of the relative abundances of neon, argon and oxygen in the nebulæ (*Nature*, **138**, 503). His further work was concerned with the recombination spectra emitted by the alkalis with the purpose of testing the applicability of the Kramers-Gaunt absorption law to these elements.

Miss M. G. Adam practically completed her investigation of the Swan spectrum in the Sun, and has used it to study the distribution of the $C_2$ molecule with height in the solar atmosphere; an account of her work will shortly be communicated to the Society. During his two months' work at the observatory Dr. H. Zanstra investigated the effect of Lyman alpha radiation-pressure on a diffuse nebula (*M.N.*, **97**, 37), and was able to show that if the nebula was sufficiently thick to be opaque the nebular atoms would stream towards the star, producing a symmetrical emission line of the type and width observed in the Orion nebula.

*Astrographic Catalogue.*—On the death of Mr. Bellamy work on the Potsdam zones of the *Astrographic Catalogue* was taken over by Mr. H. Scott Barrett, whose part-time services for this purpose the observatory owes to the generosity of the Astronomer Royal and the Radcliffe Trustees. During the year Mr. Barrett has taken with the Greenwich astrographic telescope the 32 plates needed to complete the observational part of the programme, has revised each of the measured plates under the micrometer,

and has completed the copy for press as far as 13 hours. Thus at the present observation is complete, measurement and revision over 80 per cent. complete, and re-computation of the plate constants about to commence. It is hoped that measurement will be finished in 1937, and the whole work finally rounded off in 1938.

*Seismology.*—Support of the *International Seismological Summary* for the next three years was assured by the action of the International Geodetic and Geophysical Union at its meeting in Edinburgh in September. Work on the *Summary* has gone ahead well during the year, the last three quarters for 1931 and the first quarter for 1932 having been completed. In addition Miss Bellamy has prepared an interesting and valuable geographical index to the earthquakes recorded between 1913 and 1930.

### *Norman Lockyer Observatory, Sidmouth*
### (*Director, Mr. D. L. Edwards*)

Since the last report the observatory has suffered a great loss in the death of its director, Dr. W. J. S. Lockyer, on July 15. Dr. Lockyer was buried on July 18 at Salcombe Regis near his father, the founder and first director of the observatory the interests of which they both had so much at heart.

There were 132 fine nights during the year, on 124 of which successful photographs were taken with one or more of the instruments. The 12-inch McClean telescope was used chiefly for the spectra of B-type stars, Novæ, and short-period spectrum variables. The total number of photographs taken was 295, which includes 67 spectra of Nova Lacertæ. A number of photographs of bright stars for testing the focus and other adjustments is also included in this total. The 9-inch Kensington telescope was used on bright-line stars, of which 116 spectra were taken, and the attached Zeiss triplet camera was used occasionally on star fields and Peltier's comet. The Mond photographic equatorial has recently been readjusted and focus plates have been taken of the Moon through five different colour filters, as well as of star fields and galactic clusters without filters. It is hoped to commence a regular programme of observation of the latter objects in the near future.

Investigations have been continued on Be-type stars, especially on $\gamma$ Cassiopeiæ, which still shows interesting changes. Papers on three of these stars ($\zeta$ Tauri, $\pi$ Aquarii, and $\gamma$ Cassiopeiæ) were communicated to the Society by the late director. Work has also been continued on the classification and absolute magnitudes of B-type stars, and on spectrum variables of the $\beta$ Canis Majoris type. A note on two suspected new members of the latter class has been communicated to the Society.

With the object of making more accurate quantitative work possible in the future a tube sensitometer has been installed, the principal part of which was constructed to a given specification by Messrs. Casella & Co. Preliminary experiments as to exposure time and other adjustments have been completed, and plates of stellar spectra will in future be standardised in this way. The cost of the instrument has been generously borne by Sir Robert Mond.

The staff has been augmented by the presence of Professor F. I. Blumbach, who has worked as research associate since January 31, and Mr. D. R. Barber, who was appointed assistant from September 16. In addition, Mr. E. G. Williams worked at the observatory for a short period in September on the classification of B-type stars from objective-prism spectra.

The observatory has been open to the public on Wednesday afternoons as in previous years, and also by special arrangement to larger parties. The total number of visitors during the year was 467.

The twentieth annual general meeting of the Norman Lockyer Observatory Corporation was held in London on June 9.

### *Stonyhurst College Observatory*
### (*Director, Rev. J. P. Rowland, S.J.*)

The staff of the observatory remains unchanged. The Director attended the meeting of the International Union of Geodesy and Geophysics at Edinburgh in September.

The usual routine work of the observatory has been maintained throughout the year, and the results of the magnetic and seismological observations have been forwarded to the official centres.

Drawings of the solar surface showing all spots were obtained on 255 days, and these have been supplemented by copies of drawings made at Zurich on 98 days, kindly supplied by Professor Brunner, leaving 13 days for which no statistics are available. Counts of groups and nuclei have been sent quarterly to Professor Brunner for the preparation of "Sunspot Numbers" and "Solar Character Figures," and "Daily Magnetic Character" numbers have been supplied to the International Meteorological Organisation at De Bilt.

With the approach to sunspot maximum, solar activity again shows a great increase on last year. There were no spotless days, and the mean daily area of spots, in units of 1/5000 of the disc, as deduced from the Stonyhurst drawings alone, increased from 2·84 to 5·16. The increase is attributable to the large number of groups rather than to any abnormal size of individual groups, the number of groups being 354 as against 165 last year. Three very large groups, visible to the naked eye, crossed the disc at the end of November and early December, two of them passing the central meridian on November 29. A notable magnetic disturbance started with a "sudden commencement" shortly before $0^h$ of November 29, but was of short duration, lasting only about 14 hours.

Magnetic activity, as indicated by the values of mean daily range in declination and horizontal force, showed an increase on last year, from 14′·2 to 14′·5 in declination, and from 59·3 $\gamma$ to 69·0 $\gamma$ in horizontal force. The small value in the increase of declination range must be attributed to a slight lack of freedom of the declination magnet, which was not detected till the end of the year. Applying the most probable value of the correction due to this cause, it would appear that the mean range in declination should

be increased from 14′·5 to 16′·3. According to the classification of the magnetic character of days, there was an increase of 7 in the number of "calm" days, and a corresponding decrease in each class of disturbed days. There were again no days of very great disturbance or true magnetic storms.

During the autumn a re-determination of the azimuth of the reference mark used for absolute measures of magnetic declination was made from stellar observations with a transit theodolite, and revealed an error of 2′ in the reputed value of this constant as used since 1908. In consequence, the values of declination given in our reports from that year to 1935 inclusive require to be *reduced* by this amount. It is not possible to carry the correction further back, as the reference mark used before that date is no longer available.

*Dominion Observatory, Ottawa, Canada*
*(Dominion Astronomer, Mr. R. Meldrum Stewart)*

*Meridian Work and Time Service.*—Observations on the regular programme with the meridian circle were obtained on 171 nights. Observations for clock corrections were made also on 87 nights with the small reversible transit. The synchronized time service to the various Government buildings was maintained and gave efficient service. As previously, time was distributed by clock beats over the telephone, by telegraph line and by broadcast through radio station CRCO. Continuous clock beats on the American system were sent out from the observatory transmitter on frequencies of 3332 kc., 7335 kc. and 14,700 kc. The beats of the Shortt clock were supplied continuously to the two radio monitoring laboratories. Time-signals were received regularly by wireless from Nauen, Rugby, Bordeaux, Annapolis, Monte Grande and Rio de Janeiro, and the results sent to the Bureau International de l'Heure. The usual amount of repairing and rating of watches, chronometers and other small instruments was done for the observatory and other branches of the Government service.

*Solar Physics.*—Observing conditions were below normal, but under fair conditions some 140 nine-strip spectrograms of centre, midway and points near the solar limb at various position-angles were made, also 34 photographs recording sunspots. Detailed reports were completed for publication on the measurements and re-measurements of the 1909 and 1910 spectroscopic observations of the solar rotation velocity at the equator at $\lambda$ 4250, $\lambda$ 4500 and $\lambda$ 5600. The results are in general agreement with those made in the later years and are from 5 to 8 per cent. lower than the previous observations made at Upsala, Edinburgh and Mount Wilson observatories. Similar work was continued on the observations at $\lambda$ 4250 and $\lambda$ 5600 for the years 1911–1914.

*The 15-inch Equatorial.*—The observational work during the period covered by this report was carried on with the photo-electric photometer and the spectrograph. With the latter instrument a series of plates was made of Nova Lacertæ, and some radial velocity measures were made of

Nova Herculis and of Nova Lacertæ. As in former years, the telescope was in use for public demonstrations every clear Saturday night.

*Meteor Observations.*—In conjunction with the local centre of the Royal Astronomical Society of Canada, meteor observations were planned for the Perseid and Leonid showers. Weather conditions interfered with the latter, but in August encouraging results were obtained, both by way of meteor counts at two stations occupied, and by the photography of a meteor (not a Perseid) at both stations, which made possible the computation of the height and the actual path.

*Photographic Photometry.*—Work was continued on the International Cepheid programme. Considerable time was taken up with observations of Peltier's Comet, Nova Herculis, Nova Lacertæ and the two Novæ in Aquila. Plates of the Novæ were measured, but reductions have not been completed owing to lack of the magnitudes of comparison stars in the different fields. Observations were made with the 8-inch and 6-inch cameras, and the thermopile photometer was used in measuring the plates.

*Seismology.*—During the year 321 earthquakes were recorded at the Ottawa station, and of this number 7 were reported to the Press and to Science Service at Washington, D.C. Continuous operation of short-period seismographs at Shawinigan Falls and at Seven Falls was maintained as a part of the co-operative programme for the study of seismic conditions in the province of Quebec. The auxiliary teleseismic stations at Saskatoon, Seven Falls and Halifax were operated continuously. Seismic registrations were reported regularly through the medium of a monthly bulletin distributed to the principal seismological stations of the world. The *Bibliography of Seismology* appeared regularly throughout the year. The number of publications on seismology is increasing markedly, and the ratio of scientific contribution to reviews and general reports is increasing. Study of the world records of the Timiskaming earthquake of 1935 November 1 is in progress. A series of five lectures on seismology was delivered by the seismologist at the University of Toronto in November, under the auspices of the Department of Physics.

*Terrestrial Magnetism.*—During the year observations of the three magnetic elements, declination, inclination and horizontal intensity were made at sixteen stations. Thirteen of these are repeat stations, results from which will furnish important secular change data, and three are new. Two of the latter are in the vicinity of and will replace former stations no longer available. The work was confined to the south-eastern part of Canada between latitudes 44° 38′ N. and 50° 06′ N., and longitudes 59° 58′ W. and 97° 07′ W. In addition to the field work the usual instrumental comparisons were made, utilizing for the first time a new site about ten miles south of the observatory, where two non-magnetic huts were erected. The magnetic instruments now being used by the British Canadian Arctic Expedition under the leadership of Mr. T. H. Manning were standardized, and instructions in methods of observing given to members of the party. Some valuable data from Southampton Island have been received and computed.

*Gravity.*—Seven pendulum stations were occupied in Ontario and Quebec, one of them being at Timiskaming within a few miles of the epicentre of the earthquake of 1935 November 1. The remaining six were all older stations that were re-occupied, three of these being in the vicinity of the epicentre, while the other three were at some considerable distance. The object of the work was to determine whether, as was suggested, a change in gravity had been produced by the earthquake. Comparison of the results gives no reason to suppose that any measurable change occurred.

*Publications.*—Publications during the year included five numbers of the regular series of Publications of the Dominion Observatory, namely, vol. xi, No. 3, *Gravity and Isostasy in Canada*, and vol. xii, Nos. 8, 9, 10 and 11, *Bibliography of Seismology*. Other papers published elsewhere or issued in mimeographed form include the following: "The Timiskaming Earthquake of 1935 November 1"; "Gravimetric Survey of the Malagash Salt Deposit, Nova Scotia"; "Seismological Bulletin" (monthly); "Wireless Time-Signals" (monthly); "Saturday Evening Programme" (quarterly).

### *David Dunlap Observatory, University of Toronto*
### (*Director, Professor R. K. Young*)

*Spectrographic Work.*—Work has been continued on the general programme of radial velocity determination for stars in and near the Kapteyn areas. 1024 spectrograms were secured, of which about two-thirds have been measured and the results tabulated for publication. Observation of the following eclipsing binaries has been undertaken by Dr. Hogg and Dr. Millman :—

| | | | | | |
|---|---|---|---|---|---|
| BM Cas | UX Mon | RZ Sct | BR Cyg | VW Cep | HD 183794 |
| δ Ori | W UMa | V 451 Oph | V 505 Sgr | AI Cep | HD 206155 |
| RW Mon | TX Leo | V 337 Oph | SW Cyg | VV Cep | |
| RX Gem | UW Boo | TT Lyr | MY Cyg | WY Cep | |
| TU Mon | O Her | QS Aql | BE Vul | SZ Psc | |
| | | | | Y Psc | |

These stars have been selected to avoid in general any duplication of work done elsewhere. TX Leonis has been completed and a preliminary orbit determined. Observations are practically completed for HD 183794 and HD 206155. In neither case is there any photometric orbit. The orbits of HD 25638 and HD 25639 observed at Victoria by Dr. Hogg are being completed.

The following stars are under observation for variable radial velocity :—

| | | | | |
|---|---|---|---|---|
| HD 1826 | HD 14688 | HD 44867 | HD 157482 | HD 207431 |
| „ 3081 | „ 16580 | „ 63630 | „ 158837 | „ 209813 |
| „ 5394 | „ 19536 | „ 96528 | „ 165645 | „ 209833 |
| „ 8442 | „ 26398 | „ 99832 | „ 169028 | „ 210334 |
| „ 8909 | „ 27483 | „ 142926 | „ 170474 | „ 217731 |
| „ 9709 | „ 34364 | „ 145849 | „ 176053 | „ 218767 |
| „ 10407 | „ 35189 | „ 154732 | „ 198976 | |

During the summer the nova which appeared in Lacerta was observed on every clear night with the 12-inch and 25-inch cameras and with plates sensitive in the regions 3800–6600. These are being studied photometrically by Dr. Hogg.

*Clusters.*—Dr. and Mrs. Hogg secured during the summer 112 Newtonian plates of globular clusters. Period determination is under way by Mrs. Hogg for the variables in these clusters, including a number of new ones. The one variable known in N.G.C. 6218 has been determined to be a long-period Cepheid. Seventy variables in N.G.C. 6402 have been estimated twice on 89 plates and the work of period determination is now progressing. Periods have already been determined for 3 long-period Cepheids and 8 cluster-type variables. Periods for 33 variables, all of the cluster type, have now been determined for N.G.C. 6934. This year's work increases the number of long-period Cepheids known to be in globular clusters from 15 to 20.

*Meteor Observations.*—The programmes of photographic and visual observations of the major meteoric showers have been continued. Three meteor spectrographs have been used as in 1935, and in August 1936 two of these were equipped with a rotating shutter driven by a synchronous motor. A direct camera was also used with the rotating shutter, and an interrupted Perseid trail was photographed on August 12. A number of other Perseid photographs were secured at stations co-operating with the Dunlap Observatory and 3000 visual observations of meteors made at these stations.

A study of the distribution of time intervals between meteors was published in "Meteor News," *Journal of the R.A.S.C.* A complete study of 14 meteor photographs taken with a rotating shutter at the Harvard Observatory was completed in collaboration with that observatory.

*Instrumental.*—During the past year the 19-inch telescope, which had been constructed in the observatory workshop, has been mounted. It gives excellent definition, and will shortly be equipped with a plate-holder and used for photometric work. A microphotometer of the Hartmann type has been completed. A spectral sensitometer of the rotating shutter type has been completed and was used for imprinting standardising spectra on many of the nova plates.

### *Dominion Astrophysical Observatory, Victoria, B.C.*
### (*Director, Dr. W. E. Harper*)

Two appointments to the staff were made during 1936. Mr. K. O. Wright, M.A., formerly connected with the Detroit Observatory at Ann Arbor, Michigan, and Mr. G. F. Blanchet, B.Sc., formerly with the Topographical Surveys Branch of the Department of the Interior, were appointed Assistant Astronomers and reported for duty in September and July. Dr. F. J. Neubauer of the Lick Observatory was a volunteer assistant for three weeks in July, and Dr. T. S. Jacobsen of the University of Washington spent

the month of August in a similar capacity. Both used the 72-inch telescope in obtaining spectrograms they particularly desired.

The observing weather was again considerably above the average (17 per cent.), as on 221 nights, with 1479 hours observing, 1372 plates were secured. The eighteen-year average shows 203 nights with 1260 hours observing and 1348 plates. While the general trend is towards fewer plates being secured each year, owing to increasing faintness of the stars investigated, it so happened that a considerable number of the brighter spectroscopic binaries were re-observed this year, thus accounting for the average being slightly increased.

Some alterations and additions have been made in the equipment. It was found that the large wheels supporting the dome, after eighteen years wear, had become somewhat grooved, making it hard to turn at times. Since the flanges on these 26 wheels have been ground off the dome moves freely. It was found necessary to remove the aluminium coating on the secondary mirror as it had become badly discoloured. For the present we have returned to the use of the silver coating, but it is hoped in the near future to return again to the aluminium, but deposited on a chromium base. For the benefit of our visitors, of whom we had approximately 25,556 during the past year, twenty transparencies of celestial objects, each 11 inches by 17 inches in size, with appropriate captions, have been installed on the main floor of the dome building. They are inset in the walls and illuminated from behind. Several of the negatives from which the enlargements were made were kindly loaned by Dr. R. K. Young of the David Dunlap Observatory. A step slit consisting of 10 steps with a ratio of width of adjacent steps of approximately 1·4 was secured and compared with the rotating sector as a plate calibrating device. Dr. Petrie and Dr. McKellar, who made the tests, find that in the region investigated, 4000 A. to 6500 A., the two methods are practically equivalent. Some improvements and additions have been made to the laboratory photo-electric microphotometer, and experiments by Dr. Beals with a stellar photometer, using a cæsium photo-electric cell in conjunction with a valve amplifier, have met with some success. It is hoped to initiate a programme of observation with this in the near future. A 4-inch plane grating with 15,000 lines to the inch was ruled for us by Professor R. W. Wood on an aluminium film with a substratum of chromium. The grating, which was ruled to throw as much light as possible in one first order spectrum, is reasonably fast and was designed by Dr. Beals and Dr. McKellar for use with the stellar spectrograph in the visible region. At $H\alpha$ the dispersion with the longest focus camera is 12·4 A. per mm., approximately 2·6 times that of the highest dispersion previously available with the three-prism. An adaption of the conventional measuring micrometer to a projection method has been made. An enlarged view of the spectrum and micrometer head is projected upon a viewing screen upon which a reticle is ruled. Dr. Petrie, who designed the instrument, and others who have used it, find it most satisfactory.

The director determined the orbit of the Ao star Boss 2142 from 47 single prism plates, 30 of which showed both spectra. The component spectral lines are more or less blended during most of the period of 18·772

days, hence high precision is not attained in this orbit. Additional observations of the eclipsing binary star AR Aurigæ were obtained and definitive elements determined which do not greatly differ from those of last year. An attempt was made to measure the plates of Nova Herculis obtained with the ultra-violet spectrograph in December 1934 and January 1935, but after a considerable number had been measured the radial velocities were deemed untrustworthy. For the more recent novæ our regular equipment was available and much observational material was secured. Forty-seven spectra of Nova Lacertæ were obtained during the first seven nights after discovery when rapid changes were taking place and a detailed study was made of the velocities of the various expanding shells. The novæ discovered in Aquila in September and October were observed also, though less frequently, due to their faintness.

Dr. Pearce has continued his investigations of the orbital elements and masses of eclipsing binaries. With two-prism dispersion of 11 A. per mm. at $H\gamma$ and fine-grained plates he obtained the secondary spectra in $\alpha$ and $\pi$ Andromedæ. In both cases the 1935 elements agree precisely with those obtained thirty years ago at Allegheny. The orbital elements of TX Ursæ Majoris were deduced from thirty-two observations outside of principal minimum, extending over the interval 1925–1935. The secondary spectrum of type A3 is seen during principal minimum, and from twenty-five observations at this phase the slope of the velocity curve is obtained, thereby yielding the mass-ratio. Fifty spectrograms of Nova Lacertæ yielded for the interstellar H and K lines a velocity of $-11{\cdot}04 \pm 0{\cdot}14$ km./sec., while the velocity of the $D_1$ and $D_2$ lines from three spectrograms was $-8{\cdot}9 \pm 0{\cdot}6$ km./sec. The distance of the nova determined from eye-piece estimates of the K line was 950 parsecs.

Dr. Beals completed and published (*M.N.* **96**, 661, 1936) a paper on the interpretation of interstellar line intensities. A study of the relative intensities of sodium and ionised calcium lines of stellar origin is being carried out. Preliminary results show that, while the absolute intensities of both sodium and calcium lines decrease as we go to earlier spectral types, the intensity ratio $Na : Ca^+$ actually increases to unity in some of the A and B stars. A study of the very diffuse line $\lambda$ 4429 in O- and B-type spectra, which Merrill has suggested may be interstellar, has been carried out, and there seems to be a definite correlation between the intensity of this line and the intensity of interstellar K. Material is also being collected for a paper on the P Cygni type of stellar spectrum.

Dr. Petrie has continued the spectrographic observations of eighteen bright spectroscopic binaries with a view to a redetermination of their orbital elements. High dispersion is being employed in most cases, and the observing is well on its way to completion. Three eclipsing binaries are also under observation as well as several visual binaries. The orbit of the brighter component of H.D. 109510 has been determined and further observations to secure the secondary spectrum are being made. A number of spectra of standard velocity stars of spectra Fo to K5 have been secured with high dispersion. They are being studied in connection with a proposed wave-

length table for radial velocity measures in the region λλ 3930–4494. Progress has been made in the study of the relative brightnesses of components of double-line binaries. The theory and application has been elucidated and placed upon a firm basis. A study of the colour temperature and dimensions of Nova Lacertæ has been completed.

Dr. McKellar has also studied the spectrograms of Nova Lacertæ to obtain the profiles of the emission bands. Using Zanstra's method and the intensity of λ 4640 the photo-electric temperature of the nova was computed to be 64,500° K, in substantial agreement with temperatures previously deduced for Nova Aquilæ (1918) and Nova Pictoris. The Balmer decrement in the hydrogen emission bands was shown to be essentially that obtained in similar studies of planetary nebulæ and Be stars. The spectroscopic orbits of Boss 5620 and H.D. 214652 are essentially complete, while the period of H.D. 110533 has been obtained, though a few more observations are required to complete it. The study of the Swan bands in R and N stars has been continued. In some stellar atmospheres, at least, it has been found that the relative abundance of C13 and C12 appears to be of the same order of magnitude as that found in terrestrial samples of carbon.

During the year No. 4 of vol. v and Nos. 12 to 16 inclusive of vol. vi of the *Publications D.A.O.* were put through the press and distributed. Two others were made ready for printing. Besides our seminar meetings held weekly or fortnightly as convenient, members of the staff have given 27 outside addresses and prepared 17 different papers for scientific meetings.

### *Helwan Observatory, Ministry of Public Works, Egypt*
### (*Director, Dr. M. R. Madwar*)

*Time-Service.*—The time-service was maintained as usual, the error of the standard Shortt clock No. 1 being determined from star transits. Rhythmic W/T signals were received daily from Bordeaux and Rugby during the morning, and the times of the first and last signals were determined by the aural method of coincidence (*H.O.B.* No. 28).

A new short-wave receiver with a Marconi self-recorder was lately installed at the observatory, and the Pontoise W/T signals were recorded daily during the morning.

The standard clock ran satisfactorily throughout the year, the range in the rate being $0^{s}.25$; the range in the temperature of the clock room was 18·2° C.

The reversible transit-circle has been in use and 54 transits were taken throughout the year.

*Reynolds Reflector.*—The reflector was used on 36 nights and 47 plates were exposed as follows: 17 on nebulæ, 16 on Comets Kaho, Peltier and Jackson, 5 on Nova Aquilæ, 9 on focus and test plates.

*General.*—The usual magnetic, seismological and solar radiation observations were continued.

A new Milne-Shaw seismograph, recording in the E.W. component, and a Galitzin vertical will soon be erected.

*Publication.—Helwan Observatory Bulletin*, No. 39, on the Arabic names of stars, was published and duly distributed.

### *Nizamiah Observatory, Hyderabad*
### *(Director, Mr. T. P. Bhaskaran, M.A.)*

The astrographic telescope was in regular use throughout the year ; the number of plates taken with the instrument was 124, nearly all of which were repetition plates in the region of the Hyderabad Astrographic Zones, for the determination of proper motions. Two plates were obtained with a coarse grating in front of the objective, for photometric studies, and one was exposed on Comet Peltier on July 29, when it was visible with the naked eye. Fifty-seven plates were measured in both positions for the catalogue, thus completing the measures required for the zones $+36°$ to $+39°$. The measurement of the photographs of Eros is nearly finished and the reductions are well advanced ; the work is expected to be completed during 1937.

The blink comparator (received some time ago from the Yale University Observatory) was set up and brought into regular use in November 1936. A start has been made with the comparison of the plates recently taken, with those of the old series obtained for the *Astrographic Catalogue*. Twenty-nine areas have been compared to date with this apparatus, the average interval between pairs of plates being about twenty years.

Vol. x of the *Hyderabad Astrographic Catalogue*, containing the measures of star images in zone $+38°$, has been printed and distributed. Copy for press of vol. xi ($+37°$) has been completely prepared and a part of the MS. forwarded to the printers.

The O.G. of the 15-inch Grubb equatorial had to be dismounted for internal cleaning as moisture had got into it, owing to a bad leakage in the dome before it was repaired last year. The objective was carefully cleaned and put back in its cell without much interruption to routine work. Regular observations of long-period variable stars were continued as before, and 1124 estimates of brightness were made during the year.

Forty-two occultations of stars by the Moon have been observed (disappearances 38 and reappearances 4).

Observations with the transit instrument have been taken occasionally for the determination of clock corrections.

The seismographs at the observatory (two Milne-Shaw horizontal pendulums) have registered 108 earthquake shocks during the year.

### *Kodaikanal Observatory*
### *(Director, Dr. T. Royds)*

All forms of solar activity have shown a further increase in the year 1936.

Photoheliograms were obtained on 329 days, calcium flocculi plates on

315 days, calcium prominence plates on 304 days and *Hα* flocculi plates on 276 days. One calcium flocculi plate for each day was sent to the Solar Physics Observatory, Cambridge, as in former years.

Under the auspices of the International Astronomical Union, K prominence and *Hα* disc spectroheliograms were collected from other observatories whenever complete observations were not possible at Kodaikanal. The statistical data regarding prominences seen at the limb and by absorption on the disc are published in half-yearly bulletins.

Daily character figures of solar activity according to *Hα* bright flocculi and *Hα* dark markings have been communicated to the Observatoire Fédéral, Zürich, for publication as in previous years. Daily character figures as derived from calcium flocculi from Kodaikanal photographs are furnished by the Solar Physics Observatory, Cambridge.

Observations with the Hale spectrohelioscope were made on all days except Sundays and holidays whenever weather permitted. A list of bright eruptions observed was sent quarterly to the Meudon Observatory, Paris, for inclusion in the International Astronomical Union bulletin of character figures.

*Kodaikanal Observatory Bulletin*, No. 109, containing the results obtained by the Director and Assistant Director of a photometric study of the lines of calcium and hydrogen in different parts of the Sun's disc, was sent to the press in December 1936. The values deduced for the number of atoms per cm.$^3$ at different levels in the reversing layer are given in the following table:—

*Number of Atoms per cm.$^3$ in Reversing Layer*

| Heights above Photosphere | Number of Atoms per cm.$^3$ | | |
|---|---|---|---|
| | *Ca* | $Ca^+$ | *H* (2 quantum) |
| 0–136 km. | $11{\cdot}3 \times 10^8$ | $3{\cdot}68 \times 10^{11}$ | $6{\cdot}13 \times 10^8$ |
| 0–287 km. | $9{\cdot}05 \times 10^8$ | $3{\cdot}40 \times 10^{11}$ | $3{\cdot}61 \times 10^8$ |
| 136–287 km. | $6{\cdot}95 \times 10^8$ | $2{\cdot}55 \times 10^{11}$ | $2{\cdot}01 \times 10^8$ |
| 0–600 km. | $5{\cdot}2 \times 10^8$ | $1{\cdot}7 \times 10^{11}$ | $2{\cdot}0 \times 10^8$ |
| 287–600 km. | $1{\cdot}6 \times 10^8$ | $0{\cdot}4 \times 10^{11}$ | $0{\cdot}2 \times 10^8$ |

The Director was deputed by the Government of India to observe the total solar eclipse of 1936 June 19 in Japan in order to study the effect of scattering by the Earth's atmosphere on the wave-length of Fraunhofer lines. The weather conditions prevailing at the eclipse permitted the programme of observations to be carried through almost completely. The measurement of the plates is in progress, and some comparison plates will be obtained at Kodaikanal when the sky conditions are suitable.

Mr. M. Salaruddin and the Director have measured a progressive change in the inclination of dark markings to the Sun's meridian as the life

of the markings continues. The work was not completed at the end of the year.

Mr. B. G. Narayan has been comparing the heights of individual dark markings with the height of the corresponding prominence at the limb of the Sun.

### *The Radcliffe Observatory, Pretoria*
### (*Director, Dr. H. Knox-Shaw, Radcliffe Observer*)

Last year's report told of the closing of the observatory in Oxford. As during the year under review active preparations have been made for the reopening on the new site near Pretoria, it seems the right moment for the report to make its first appearance amongst those of the observatories of the Dominions.

Good progress has been made by Sir Howard Grubb, Parsons & Co., with the mechanical parts of the 74-inch reflector, most of which were ready for assembly at the works by the end of the year. The large pyrex disc was cast by the Corning Glass Co. in July, and is expected to arrive in Newcastle early in the new year.* An order has been placed with Messrs. Adam Hilger Ltd. for the optical parts of a two-prism spectrograph for use at the Cassegrain focus. The design of the mechanical parts of this spectrograph and of one for use at the coudé focus is still under consideration. The telescope will be housed in a cylindrical turret, and the observing carriage for the Newtonian focus will be somewhat similar in design to that of the 60-inch reflector at the Harvard Boyden Station near Bloemfontein.

The Director left England at the end of August on a visit to South Africa to prepare final building plans with the architect, Mr. Gordon Leith. These were completed in time to invite tenders before the end of the year. It is expected that the contract for the residences, office block and base for the turret will be signed in January, and that building will commence forthwith. This should be completed soon after the middle of 1937, when the erection of the steel turret and telescope will commence. The Municipality of Pretoria and various departments of the Union Government are rendering most valuable assistance. The Municipality, in addition to presenting the Radcliffe Trustees with the site of 57 acres, are bringing electric power and water to it. The latter operation involves the laying of over three miles of pipes, the construction of a reservoir and the installation of a pump.

### *Union Observatory, Johannesburg*
### (*Union Astronomer, Mr. H. E. Wood, M.Sc.*)

26½-*Inch Grubb Visual Refractor.*—The number of visual micrometrical measures of double stars made during the year was 4000.

With the eyepiece interferometer 36 measures of suitable double stars were obtained ; 27 photographic plates of double stars were taken.

* The disc when taken from the annealing oven was found to be useless. This catastrophe will cause about nine months delay in the completion of the telescope.

The novæ in Aquila and Sagittarius were scrutinised for duplicity ; Nova 618·1936 Aquilæ was found to be double, distance 0″·18, position angle 140° (1936·75).

*Occultations of Stars by the Moon.*—The regular programme of observations of occultations of stars by the Moon has been continued, and 180 occultations were observed during the year.

The results of the year's observations are as follows :—

| | | s | ″ |
|---|---|---|---|
| | 1936·15 | 6·4 | 3·5 |
| | ·41 | 6·5 | 3·6 |
| | ·67 | 5·6 | 3·1 |
| | ·87 | 5·4 | 2·9 |
| Mean for year | ·55 | 6·0 | 3·3 |

These results are, as in former reports, deduced from disappearances at the dark limb only. The second column indicates the time by which the Moon has arrived too early at any longitude, and the third column the amount by which the Moon is ahead of its tabular longitude. In obtaining the means, each occultation is given a weight equivalent to $\cos(\chi - \rho)$, and no occultation is included for which the value of $\cos(\chi - \rho)$ is less than 0·5.

*Franklin-Adams Star Camera.*—During the year 1185 plates were taken with this instrument. The distribution of the plates was as follows :—

| | |
|---|---|
| Minor planet regions and star maps ... ... ... | 397 |
| Variable star regions ... ... ... ... ... | 697 |
| Comet regions ... ... ... ... ... ... | 91 |

Comet 1936*c* was found by Mr. C. Jackson when photographing minor planet zones, and was observed here from September 15 to October 19. This comet has been found to have a period of about eight years. Comet 1936*a* (Peltier) was observed from August 3 to October 19. Comet d'Arrest, 1923 II, was unsuccessfully searched for in August and September.

87 new minor planets were discovered during the year, and elliptic orbits were computed for 9 new minor planets. 768 approximate positions and 86 accurately measured positions of minor planets were forwarded to the Astronomisches Rechen-Institut. A long series, from 1936 March 6 to August 1, of short-exposure photographs of Ceres near meridian passage was made and the measurements published in *A.N.*, No. 6251.

*Union Observatory Circulars.*—Circular No. 95, with 11 Southern Star Maps, was distributed during the year, and Circular No. 96 is in the press.

*Miscellaneous.*—Mr. W. M. Worssell retired on superannuation on 1936 November 5 after 27 years' service at the observatory.

Dr. H. van Gent of the Leiden Observatory has continued his photographic observations of variable stars throughout the year.

The number of visitors to the observatory during the year was 1884.

*Adelaide Observatory*
*(Director, Mr. G. F. Dodwell, B.A., Government Astronomer)*

The routine work of the observatory has been continued as in previous years.

In regard to the International Latitude Observations, 1274 pairs of latitude stars were observed on 129 nights. During the first half of the year the observers were Messrs. A. L. Dawson, B.Sc., and A. E. Markey. Mr. Dawson was transferred to the Actuarial Department at the end of July, and later in the year assistance was given in this work by Mr. R. V. Burton. The results of the observations are now sent to Professor L. Carnera, Director of the Royal Astronomical Observatory at Capodimonte, Naples, who was appointed by the International Astronomical Union to be Director of the Central Bureau of the International Latitude Service, following upon Dr. Kimura's retirement.

Magnetic observations have been continued, and the magnetic elements were determined at several field stations. Corrections to our instrumental constants, to reduce them to the international standards, were obtained by intercomparison with the field instruments of the Watheroo Observatory, the comparison being made at the National Park, Belair.

It is interesting to note that the increase in the easterly variation of the compass, generally observed in South Australia in recent years, is still going on. At Adelaide the magnetic declination at the beginning of 1936 was 6° 1′ east of north. Prior to 1923 it remained stationary for many years at 5° 36′ east of north.

Preparations are being made for the gravity survey expected to be made this year by Mr. Colin Kerr Grant in the Rift Valley formations bordering on the Mount Lofty and Flinders Ranges.

A study of ancient and mediæval observations of the obliquity of the ecliptic has been continued. The errors to which the ancient observations were liable have been investigated, and light has been thrown on this subject by experimental tests, using instruments and methods similar to those of ancient times.

*Commonwealth Solar Observatory, Canberra, Australia*
*(Officer-in-Charge, Mr. W. B. Rimmer)*

*Sun Telescope.*—A Kipp and Zonen infra-red spectrograph has been used, in conjunction with the Sun telescope, to determine the water-vapour content of the atmosphere in the path of the Sun's rays at, or near, apparent noon of each day. The intensity of the water-vapour absorption bands in the solar spectrum at 9300, 11,300 and 14,700 A. have been measured, and the values of the water-vapour content deduced according to the method developed by Dr. F. E. Fowle of the Smithsonian Institution. These results have been used to calibrate the spectroscopic method, mentioned in last year's report, in which the intensities of 18 water-vapour lines in the

yellow region of the solar spectrum are compared with those of 15 adjacent solar lines. The individual results obtained from simultaneous observations by the two methods are in good agreement.

Psychrometric observations of the water-vapour pressure at the Earth's surface also were made at the same time, and values corresponding to the above were deduced by Hann's equation. The constant of this equation required to be adjusted to give the same values in the mean; the individual values showed, however, greater divergences than those obtained by the spectroscopic methods.

*The Hale Spectrohelioscope.*—This instrument has been equipped with a Standard Rowland grating, and was brought into regular operation in 1936 June. Routine observations have been made daily during the hours 2300 to 0300 U.T., and a monthly summary forwarded to Dr. L. d'Azambuja at the Paris Observatory, for insertion in the I.A.U. *Bulletin for Character Figures of Solar Phenomena.*

*Atmospheric Ozone.*—Measurements of the ozone content of the atmosphere have been continued since 1929, using a Dobson spectrograph. An improved Dobson photo-electric spectrophotometer for this work has recently been ordered.

*Atmospheric Electricity.*—Continuous records of the potential gradient, as well as daily measurements of the conductivity, number and mobility of the small ions have been continued. The automatic recording of the mean life, rate of production and concentration of the small ions has also been carried on.

*Cosmic Radiation.*—A pressure ionisation vessel has been operating continuously in a thermostatically controlled chamber since 1935 July. The results obtained are being subjected to statistical treatment to eliminate barometric and outdoor temperature fluctuations, so that corrected diurnal variation curves of the cosmic radiation intensity may be obtained.

A second ionisation vessel has been constructed and is being used for the investigation of bursts.

*Radio Research.*—Observations with the Cathode Ray Direction Finder and Continuous Recorder for the location of thunderstorms in and around Australia have been continued in co-operation with an officer of the Commonwealth Meteorological Bureau, as in the previous year.

Almost continuous records have been made of the heights of the ionospheric reflecting layers for a frequency of 2·8 megacycles per second, and on a number of occasions determinations of the ionisation densities of the various layers have been made. Automatic $P'-f$ apparatus, to determine ionisation densities, has been supplied by the Radio Research Board of the Council for Scientific and Industrial Research, and this is being calibrated and adjusted to cover a range of frequencies of 2·2 to 12·0 mc/s.

*Publications.*—Publications during the year include: "The Mobility of the Small Ions of the Atmosphere," *Gerlands Beiträge zur Geophysik* (**47**, pt. 1/2, pp. 31-59, 1936); "Bursts of Cosmic Radiation," *Nature* (**138**, p. 77, 1936); "The Brightness of the Sky, with Special Reference to the Region within 3° of the Sun," *Gerlands Beiträge zur Geophysik* (**46**, pt. 1/2,

pp. 32–43, 1935). Also two papers, "Observations of Atmospherics with a Narrow Sector Directional Recorder at Canberra," and "Characteristics and Distribution of Sources of Atmospherics," appeared in *Bulletin* No. 100 of the C.S.I.R. (Report No. 10 of the Radio Research Board); this work was carried out jointly with the Radio Research Board of the Council for Scientific and Industrial Research.

*General.*—The programme of work, as outlined in the reports of previous years, has been continued.

### *Melbourne Observatory*

(*Dr. J. M. Baldwin, M.A., D.Sc., F.Inst.P., Government Astronomer*)

The main astronomical observational work for the year has been devoted to the list of Fundamental Stars with the 8-inch transit-circle, and the reduction of these observations has taken up much of the time of the staff. In addition some further revision had to be given to the catalogue Me 5. The 8-inch transit-circle was out of commission for over three weeks while the roof was being repaired. Owing to this, to unusually cloudy weather in the latter part of the year and to the depletion of the observing list, the number of observations has been less than usual.

The observation of southern long-period variable stars with the 8-inch equatorial has been continued, but for various reasons the number of observations has been considerably below the average. These observations have been published in the *Harvard Annals* with those of other members of the American Association of Variable Star Observers.

No progress has been possible with the printing of the fourth and fifth *Melbourne General Catalogues*, or with vols. iv and v of the *Astrographic Catalogue*. The only work that has been possible on the *Astrographic Catalogue* has been the computation of the definitive plate constants, which is now complete for all plates from $-65°$ to $-75°$.

During the year an apparatus for star corrections, following in the main that described by W. E. Cooke in *M.N.*, **55**, 288, 1895, was constructed. Tests indicate that considerable time will be saved in checking these corrections. The apparatus was made of steel sheet, coated with duco. The lines were ruled on this with indian ink, and then the whole was covered with clear varnish. The result is very satisfactory.

Seismological and magnetic work has been carried on as usual. Seismological bulletins have been issued quarterly, and a volume containing hourly values of the magnetic elements at Toolangi for the years 1932 and 1933 is in the press and will be distributed early in 1937. An inter-comparison of the absolute instruments used at Toolangi with a set belonging to the Department of Terrestrial Magnetism of the Carnegie Institution of Washington was made in August.

*Riverview College Observatory. Sydney, N.S.W.*
*(Director, Rev. W. O'Leary, S.J.)*

During the year 932 plates were taken in continuation of the programme of work on variable stars, as well as a number of plates of Comet Peltier. Studies of a number of variable stars have been prepared for publication in the Lembang Observatory *Annals* and the Riverview *Publications*. Orbits have been computed for some eclipsing binaries, using the photographic light curves determined here.

Occultations of stars by the Moon have been observed whenever possible, the number of clear nights being well below the average.

*Publications.*—Riverview *Publications* 1 and 2 have been distributed. Two lists of new variable stars, with provisional elements have appeared in the *Astronomische Nachrichten.*

*Seismology.*—The recording pens of the Wiechert horizontal seismograph have been redesigned, the system being made both simpler and more efficient. 213 earthquakes have been recorded during the year. The work of publishing the monthly bulletins has been kept up to date.

*Sydney Observatory*
*(Director, Mr. James Nangle, Government Astronomer)*

Work on the Astrographic Catalogue has proceeded as usual. Two additional volumes, namely vols. xiii and xiv, will be ready for publication shortly.

Successful observations were made of Comet Peltier and the results have been published.

The usual routine work necessary for civil purposes, including the determination and distribution of standard time, has been carried out.

157 tremors have been recorded on the Milne seismograph and monthly bulletins have been forwarded to the principal seismological stations.

1647 visitors have been conducted over the observatory and lectures on astronomy have been given to University and other students. Lectures on popular astronomical subjects have been broadcast.

Mr. W. E. Raymond retired in April 1936, and Mr. H. W. Wood, M.Sc., a distinguished graduate of the Sydney University, has been appointed to the staff and commenced duties at the beginning of the year.

The building and equipment of the observatory have been maintained in good order.

*Dominion Observatory, Wellington, New Zealand*
*(For the Year 1935)*
*(Acting Director, Mr. R. C. Hayes)*

*Time Service.*—The time service has been maintained as in previous years. The observatory clocks are rated by means of radio time-signals and by transit observations.

*Longitude Observations.*—The work of reducing the observations made in

1933 October–November for International Longitude Determination was nearing completion by the end of 1935. When the work is completed the detailed results will be sent to the Bureau des Longitudes, Paris. A summary of the results is to be published as a bulletin of this observatory.

*Sunspot Observations.*—Observations of sunspots were made by Mr. I. L. Thomsen of the observatory staff, using the 5-inch refractor of the Wellington Philosophical Society's Observatory. During the year 1935, observations were made on ninety-two days. The results of the sunspot observations have been sent to Zürich, according to arrangements with the International Astronomical Union.

*Occultations.*—Observations of occultations of stars by the Moon have been carried out during the year, and the results sent to the British Nautical Almanac Office. This observatory is indebted to the New Zealand Astronomical Society and to the New Plymouth Astronomical Society for co-operation in observing occultations, and to the Wellington City Council for making their 9-inch refractor available for these observations.

*Work with 5-inch Cooke Refractor.*—During the year 1935, astronomical observations were made by Mr. M. Geddes, Otekura, Southland, using a 5-inch Cooke Refractor belonging to this observatory. Mr. Geddes's observations have been published from time to time in the Bulletins of the New Zealand Astronomical Society.

*Seismology.*—The observatory has continued to record both local and distant earthquakes and to collect and classify reports of earthquakes felt in New Zealand. During the year 1935 one hundred and fifty earthquakes were felt in some part of New Zealand. Of these, one hundred and three were felt in some part of the North Island, and fifty-four in some part of the South Island. Seven were felt in both islands. The maximum intensity reported during the year was seven on the Rossi-Forel Scale. This occurred in the Taupo district on 15th July. The seismographs of this observatory recorded five hundred and thirty-four earthquakes during the year. This number included both local and distant shocks of all magnitudes. During the year a new seismograph station was established at Lake Monowai, Southland, by courtesy of the Southland Power Board. Mr. R. C. Hayes, Professional Assistant, and Dr. L. Bastings, Honorary Research Associate in Seismology, carried out research work in seismology, and the following special papers were published during the year :—

"Focal Depth of the Pacific Earthquake of 1933 September 6" (R. C. Hayes).

"Earthquake Distribution in New Zealand, 1848 to 1935" (L. Bastings and R. C. Hayes).

"A New Type of Seismological Table for Distant Earthquakes" (L. Bastings).

"A Summary of New Zealand Earthquakes for the Period 1903 to 1920" (R. C. Hayes).

"Shear Waves through the Earth's Core" (L. Bastings).

"Destructive Earthquakes in New Zealand, 1835 to 1934" (L. Bastings).

"Earthquake Frequency in New Zealand" (R. C. Hayes).

*Publications.*—Preliminary earthquake bulletins giving readings from this observatory and the subsidiary stations were published monthly. These bulletins included separate preliminary seismological reports from the Magnetic Observatory, Christchurch, and a list of provisional corrections to radio time-signals sent out by this observatory. Complete seismological reports for the whole of the year 1933 were published as quarterly bulletins E 36, E 37, E 38, E 39. The seven special papers mentioned above on seismology were published during the year as Bulletins 94, 95, 98, 99, 100, 103, 104.

The Report of the Dominion Astronomer and Seismologist (Dr. C. E. Adams) for the year 1933 was published as Dominion Observatory Bulletin 95, and extracts of the article on Earthquakes prepared by Dr. C. E. Adams for the *New Zealand Official Year-Books* 1935 and 1936 were published as Dominion Observatory Bulletins 97 and 102. Articles on the Time Service were prepared for the *Official Year-Book* 1936 and for the *New Zealand Nautical Almanac* 1936.

### *Mr. Robert Barker's Observatory, Cheshunt, Herts*

Despite the worst year on record for observations, a certain amount of definite work was accomplished.

58 observations on Saturn's satellites were made, and estimates of variability formed, especially on Enceladus.

Two shadow transits of Dione were seen, and some new lunar features discovered and investigated.

### *Mr. A. F. Bennett's Observatory, Leiston, Suffolk*

Work has been continued on the Sun, and the Cooke refractor has been used for observations of the planets, novæ and variable stars. Reports of occultations of stars by the Moon, observed during the year, have been sent to the Computing Section of the B.A.A. Since the last report a Synchronome sidereal clock, transmitting seconds to a dial in the observatory, has been added to the equipment.

### *Mr. J. Evershed's Observatory, Ewhurst, near Guildford*

Spectroheliograms in $H\alpha$ light for the estimation of character figures were obtained on 110 days during the year, and prominence plates on 93 days. The general increase of solar activity is indicated by a great development of the absorption markings, especially during May and in October. Emission markings near spot-groups have also increased, and bright eruptions on the disc in which the $H\alpha$ line was comparable in intensity with the continuous

spectrum were recorded on April 10, $9^h\,42^m$ U.T.; May 6, $9^h$; May 16, $7^h\,13^m$; August 1, $7^h\,9^m$; and December 30, $10^h\,33^m$ and another at $11^h\,20^m$.

Eruptive prominences on the limb were photographed as follows:—February 12, S.E. limb; April 23, E. limb; May 6, S.W. limb; August 22, S.E. limb; and September 29, N.W. limb. The greatest height recorded was 5′ on August 22.

89 spectra of prominences have been photographed, and measures of the shifts of the emission lines H and K with reference to the calcium lines in the arc are being continued to obtain further values of the solar rotation at high levels, and of the general shift of these lines towards red in different solar latitudes.

A large amount of experimental work has been done with the object of improving the performance of the high-dispersion spectrograph which employs a hollow prism containing ethyl cinnamate. Mr. Hargreaves has co-operated in this work, and he has succeeded in perfecting the optical quality of the prism so that by multiple transmission, employing two plane mirrors, light may be sent 6, 8 or even 10 times through it in the green, yellow or red region respectively without loss of critical definition. With 4 transmissions only in the more refrangible regions the spectra rival in resolving power those obtained with the largest gratings.

With 4 transmissions a series of arc spectra of iron and carbon have been obtained, and from these accurate measures of the wave-lengths of H and K have been made, using the secondary standards of iron.

*Publications.*—"The Red Shift of the Iron Lines at the Edge of the Sun," *M.N.*, **96**, 152–159.

### *Mr. F. J. Hargreaves's Observatory, Kingswood, Surrey*

The usual observations of the physical features of Jupiter were made, but these were much fewer than in previous apparitions owing to the low altitude of the planet.

Two diagonals for the $14\frac{1}{4}$-inch reflector, one of ordinary glass and another of low-expansion glass one inch thick, were found to become distorted in conditions of rapid change of temperature. A third diagonal, of low-expansion glass only five-eighths of an inch thick, has been found to be free from this defect, the image being free from astigmatism at all times.

A large-diameter eye-end adaptable for photographic use has been made and fitted to the reflector. The focussing movement is effected by three screws and nuts spaced 120° apart and geared together by a chain. This has been found much steadier and more satisfactory generally than the usual rack-and-pinion motion.

### *Mr. W. T. Hay's Observatory, Hendon*

During 1936 observations have been made mainly for obtaining comet positions. Positions of Comet Peltier (1936 *a*) were obtained on fourteen nights between 1936 May 19 and August 1. The comet was photographed

on six nights. (Zeiss triplet $f5$, 25-inch focal length.) Positions of Comet Kaho were obtained on four nights between 1936 July 25 and August 2.

The total solar eclipse of 1936 June 19 was observed from the bridge of R.M.S. *Strathaird* in the Ægean Sea, photographs and cinema-film being taken with satisfactory results.

A new Blink microscope has been completed (for half-plates) and is now available for use. Work has been commenced on a second instrument for Dr. R. L. Waterfield.

### *Dr. J. L. Haughton's Observatory, Teddington*

The work on lunar occultations has been continued, twelve having been observed.

About forty stellar photographs have been taken, mainly in a search for novæ.

The solar eclipse of June 19th was observed from the S.S. *Strathaird* off the coast of Greece ; some photographs were taken and the air temperature during the eclipse was measured.

### *Mr. F. M. Holborn's Observatory, Streatham Hill, London*

Observations were made on 161 nights during the year. Visual estimates of brightness of Nova Herculis were made on 65 nights and of Nova Lacertæ on 59 nights. 1812 observations were made of 58 variable stars. All records were sent to the British Astronomical Association.

### *Mr. A. M. Newbegin's Observatory, Worthing, Sussex*

The usual routine work on prominences and sunspots has been carried out with the $6\frac{1}{4}$-inch Cooke equatorial and 109 observations were made, but throughout the year adverse weather seriously interfered with the results.

The spectrohelioscope was in use on about 100 days, special attention being given to bright $H\alpha$ eruptions, the results of which were sent quarterly to M. d'Azambuja in accordance with the requirements of the International Astronomical Union. In addition, the positions of all bright and dark hydrogen flocculi were recorded, and a large number of radial velocity measurements of dark flocculi associated with sunspots were made.

Some remarkable dark flocculi were observed which had no connection with sunspots, and one was recorded in the southern hemisphere lasting for 10 days, which culminated on August 31 in the largest prominence seen for many years at this observatory. Its greatest height was recorded at 350″, and at its highest point radial velocity measurements indicated a movement inwards of 122 km./sec. A remarkable feature of this display

was the duration of metallic activity, which persisted for at least five days, but the eruptive state was of less than 30 minutes duration.

The 9-inch Coudé telescope, in the hands of Mr. B. L. Pitcher, has been in use on many nights on the Moon and some of the more open clusters, but a definite programme of work for this instrument is yet to be decided upon.

*Mr. B. M. Peek's Observatory, Solihull, Birmingham*

Physical observations of Jupiter have been carried on as usual, the amount of work having, however, been considerably restricted owing to the low altitude of the planet. Observations have also been made of Saturn, principally in connection with the approach of the Earth and Sun to the ring plane.

Photometric observations of Nova Persei 1901 and of Nova Herculis 1934 have been continued, and a few estimates of the magnitude of Nova Lacertæ 1936 were made near the time of maximum. Observations of SS Aurigæ and U Geminorum have been resumed at the request of the Variable Star Section of the B.A.A.

Twenty-one occultations of stars by the Moon were recorded in 1936.

Towards the end of July photographs were obtained with the Watson and Cooke cameras (the latter kindly lent by Mr. Percy Morris) of Comet 1936 *a* Peltier. One of the Cooke negatives showed 3 degrees of tail.

The 12¼-inch Calver mirror, refigured by Mr. F. J. Hargreaves and kindly lent by Rev. T. E. R. Phillips, is still employed in the main instrument and is giving most satisfactory results.

*The Rev. T. E. R. Phillips's Observatory, Headley, near Epsom*

The usual programme of work on planets and double stars was continued.

Jupiter was again very badly placed for observation. The number of spot transits secured was 427.

Observations of Saturn and his satellites were greatly interfered with by the cloudy conditions generally prevalent. Overcast skies made it impossible to get any observations at all during the very close appulse of the ring plane to the Earth at the end of June, and greatly hindered work when the plane passed through the Sun at the end of December. Nothing was seen of the rings after December 27. Some measures of Saturn's belts were made during the summer and autumn.

Owing to pressure of other duties and illness, Dr. Waterfield was unable to continue the photographic work with the 6-inch Cooke triplet. Three photographs of Comet Peltier were, however, secured, two of which showed a double tail, one nearly straight and one markedly curved. From February onwards he was occupied in the preparation for, and the observation of, the total solar eclipse of 1936 June 19. Conditions on the Island of Chios in the Eastern Ægean were very favourable, and the programme of work was carried through successfully.

The Twenty-eighth Report of the Jupiter Section of the B.A.A. has been presented to the Association, and is now in the Press.

The meteorological observations have been continued. The rainfall in 1936 was again very heavy, reaching 38·28 inches, or more than 6 inches above the average of the previous twenty years.

### *Mr. F. J. Sellers's Observatory, Muswell Hill, London*

The usual daily routine observations of the Sun have been made with the 5-inch equatorial and solar spectroscope. These have been recorded and charted, and quarterly summaries published in the *B.A.A. Journal.*

An increase in the mean daily frequency of spot-groups during the year of from 4·4 to 7·0, and of prominences from 11·6 to 19·0, is apparent from these observations.

A small photoheliograph is being mounted on the equatorial for recording the positions of sunspots more quickly and more accurately.

The fixed spectrohelioscope, mentioned in the last report, is now completed, and will be in daily use, whenever observation is possible, from 1937 January.

Observations of several lunar occultations have been made and reduced for communication to the B.A.A. Computing Section.

### *Dr. W. H. Steavenson's Observatory, West Norwood*

Observations were made on 167 nights during the year.

The usual photometric observations of novæ and faint variable stars were continued with the 20½-inch Hindle reflector.

355 observations of 16 novæ were made, and some of the results have already been communicated to the Society. In addition, 175 observations of 18 long-period and irregular variable stars have been made, and these have been communicated to the Variable Star Section of the British Astronomical Association.

Comet Peltier was observed for position on 16 nights and the results of the measures have been communicated to the Society.

The mirrors of the telescope were silvered on 1936 April 12 and November 29.

### *Wolsingham Observatory (Rev. T. E. Espin's), Tow Law, Co. Durham (Observer, W. Milburn)*

The usual programme of remeasurement of certain known double stars, chiefly those of Espin and Milburn, has been continued with the 24-inch (Calver) reflector, together with the survey for new double stars in the zones $+35°$ to $+40°$. The results have been communicated to the Society. The new dome is not yet in proper working order, with the result that only a very small part of the sky has been available for examination. A new shutter of improved design is being installed and should be completed soon. Nova Lacertæ (1936) has been under observation since August.

## NOTES ON SOME POINTS CONNECTED WITH THE RECENT PROGRESS OF ASTRONOMY

### *Minor Planets*

The lettering gives the approximate date of discovery; in the first half of January the first letter is A, in the second half B, the first letter changing every half-month; I, J being treated as a single letter, December discoveries begin with X or Y.

Two hundred and sixty-two planets were discovered, or first announced, in 1936, as follows :—

R. Abahazi and G. Kulin (Budapest) QG, RD, TC, TD, TE, TF, TG, YA; A. Bohrmann (Heidelberg) DC, DO, FY, FZ, $FB_1$, $QC_1$; L. Boyer (Algiers) CD, FM, FO, MA, WA, XB; R. Carrasco (Madrid) 1935 YA, 1935 YD; E. Delporte (Uccle) BA, CA, EA, FD, FE, FF, FG, FH, FJ, FK, FL, FN, FS, FT, FU, FV, FW, PA, TA, XA, YC; M. Djurkovic (Uccle) FA, FC, GA; Hunaerts (Uccle) HA, HB, KA, QM, QN, QO, QP; C. Jackson (Johannesburg) 1935 WC, 1936 BB, BC, BD, DH, DJ, DK, DN, FN, $FC_1$, $FG_1$, $FJ_1$, $FK_1$, $FL_1$, $FM_1$, HJ, HK, HL, HM, HN, KD, KE, KF, KH, KJ, KK, KL, LA, LB, LC, LD, LE, LF, LG, MB, MC, MD, ME, MG, MH, MJ, NA, NB, NC, ND, NE, OJ, OK, OL, OM, ON, OO, OP, PD, PF, PG, PH, PJ, PK, PL, PM, PN, PO, PP, PQ, QO, QQ, QS, RH, RJ, RK, RL, RM, SE, SF, SG, SH, SJ, SK, SL, SM, SN; M. Laugier (Nice) CC, DL, DM, $FN_1$, $FO_1$, $FP_1$, HC, HD, JA, KB, MF, OE, UA, UB, UD, UE, UF, UG, UH, UJ, VA, VB, VD, VE, VF, VJ, WD, YD, YE, YF, YH; K. Müller (Bergedorf) FB; G. Neujmin (Simeis) 1935 YB, YC, 1936 AA, AB, AC, AD, FC, $FC_1$, $FD_1$, $FE_1$, $FF_1$, $FH_1$, HG, HH, OG, OH, PB, PC, QA, QD, QH, QJ, $QK_1$, SB, SC, SD, UA, UK, WE, XC; A. Patry (Nice) VG, VH, YB; J. Piegza (Krakow) HE; M. Protic (Belgrade) TB; K. Reinmuth (Heidelberg) DE, DF, DG, EB, FA, $FA_1$, KC, KG, OA, OB, OC, OD, QC, QE, QF, QV, QW, QX, QY, QZ, $QA_1$, $QB_1$, $QD_1$, $QE_1$, $QF_1$, $QG_1$, $QH_1$, WE, WF, YG; G. Reiss (Algiers) HF, WB; F. Rigaux (Uccle) DB, PB, QK, $QL_1$, RB, RC; R. Suvanto (Turku) FP; Y. Väisälä (Turku) DA, DD, FQ, FR, FX, QL, RE, RF, UC, UL, WC; G. van Biesbroeck (Yerkes) 1935 YE; H. van. Gent with G. Pels (Johannesburg) 1935 YF, YG, 1936 DP, DQ, $FQ_1$; A. A. Wachmann (Bergedorf) RC, RG, SA.

K. Reinmuth was assisted by W. Jahn, and G. Neujmin by Ganscha.

The following identities are announced and numbers assigned :—

99 = 1935 UC; 496 = 1936 CB; 522 = 1936 QP; 809 = 1936 VC; 854 = 1935 QE; 872 = Σ14; 1010 = 1908 ER; 1245 = Σ19; 1248 = Σ13; 1291 = 1931 DX; 1332 = 1924 QY; 1341 = 1932 NK; 1345 = 1908 CG = 1932 EA = 1932 FB; 1346 = 1929 CY = 1931 RC; 1347 = 1898 DW = 1931

VW (observed 1935); 1348 = 1933 FD = 1934 LG; 1349 = 1934 LJ = 1934 NH (observed 1935); 1350 = 1934 TA (observed 1936); 1351 = Σ95 = 1928 QJ = 1934 TF (observed 1935); 1352 = 1935 CE; 1353 = 1920 HB = 1935 CU (observed 1936); 1354 = 1930 KG = 1935 GK; 1355 = 1935 HE; 1356 = 1935 JH; 1357 = 1935 ND; 1358 = Σ58 = 1935 OB; 1359 = 1903 MT = 1935 OC; 1360 = 1935 OD; 1361 = 1935 QA; 1362 = 1935 $QG_1$; 1363 = 1935 RA; 1364 = 1935 VB; 1365 = 1928 RK = 1932 WL; 1366 = 1932 WA = 1935 GM = 1935 JM; 1367 = 1934 NA; 1368 = 1928 SN = 1935 HD; 1369 = 1928 FE = 1935 QB; 1370 = 1935 QG; 1371 = 1933 $FD_1$ = 1935 QJ; 1372 = 1928 DX = 1935 QK; 1373 = 1935 QN; 1374 = 1935 UA; 1375 = 1933 FC = 1935 UB; 1376 = 1935 UH; 1377 = 1936 CD; 1378 = 1915 KW = 1936 DB; 1379 = 1936 FC; 1380 = 1936 FM. Also 750 probably = 1932 JB.

The numbers from 1345 onwards are new; 496 had been missing since 1902.

Among the unnumbered planets :—

1903 MT = 1935 OC; 1914 VK = 1935 SS; Σ58 = 1935 OB; 1920 HB = 1935 CU; 1928 DS = 1931 TT; 1930 KG = 1935 GK; 1930 OB = 1935 OA; 1931 FK = 1934 TF.

The following planets have been named :—

1005 Arago; 1006 Lagrangea; 1007 Pawlowia; 1062 Ljuba; 1084 Tamariwa; 1086 Nata; 1227 Geranium; 1228 Scabiosa; 1231 Auricula; 1232 Cortosa; 1233 Kobresia; 1246 Chaka; 1248 Jugurtha; 1264 Letaba; 1268 Libya; 1271 Isergina; 1278 Kenya; 1279 Uganda; 1311 Knopfia; 1315 Bronislawa; 1318 Nerina; 1319 Disa; 1328 Devota; 1334 Lundmarka; 1335 Demoulina; 1336 Zeelandia; 1337 Gerarda; 1338 Duponta; 1339 Desagneauxa; 1340 Yvette; 1341 Edmée; 1342 Brabantia; 1343 Nicolle; 1344 Caubeta; 1352 Wawel; 1353 Maartje; 1361 Leuschneria; 1364 Safara; 1366 Piccolo; 1374 Isora; 1376 Michelle; 1378 Leonce; 1932 HA Apollo; 1936 CA Adonis.

The most interesting discovery of the year was 1936 CA, discovered by Dr. E. Delporte at Uccle on February 12; its magnitude was 13, and its daily motion $-5^m\ 36^s$, S. 1° 30′. When approximate elements were found it was seen to have passed within $1\frac{1}{2}$ million miles of the Earth a few days before discovery. This distance is the same as that of Lexell's comet in 1770. The orbit approaches still closer to that of the Earth, the least distance being $1\frac{1}{3}$ million miles. The inclination being small, the orbit also approaches closely to those of Venus and Mars, and its perihelion is not far from the orbit of Mercury. It was desirable to observe it over a long arc, to facilitate its recovery at future returns. This end was secured with the aid of the two great American reflectors, Dr. Jeffers obtaining photographs on March 12, 13, 16, the magnitude being 19·5 (*U.A.I. Circ.*, 582), and Dr. Nicholson with the 100-inch on March 12, 27 and April 11, the magnitudes on the three days being 18·5, 19·5 and 20·5, the last being a record for a planetary body; the last image was well defined, and was compared with six stars in *Bordeaux*

*Astrogr. Cat.* (*Harvard Obs. Card*, 371). The name Anteros was widely used at first for CA, but proved to be unofficial. The adopted name is Adonis, and the name Apollo was given to the planet 1932 HA (Reinmuth), which has a similar orbit. The period of Adonis is in the neighbourhood of 2·54 years, but a definitive orbit is not yet to hand. The diameter is probably less than one mile. The planet 1936 BD (Jackson) had the rapid northerly motion of 29′ daily. Another interesting planet is 1936 QW (Reinmuth). From Heidelberg positions of August 17, 28 and September 10, Mr. Schürer deduced that it is an eleventh member of the Trojan group, on the side of Jupiter of greater longitude. There are now six known members on this side and five on the other. QW has the small eccentricity 0·071, but the large inclination of 19°·4 (*R.I. Circ.*, 1443). A. C. D. C.

### *Comets*

Three comets, discovered in previous years, remained under observation for several months of 1936; these were 1934 *c* (Schwassmann-Wachmann (2)), 1935 *c* (Comas Sola) and 1935 *d* (van Biesbroeck). An improved orbit of the last is given below.

Comet 1925 II (Schwassmann-Wachmann (1)) does not seem to have been observed in 1936; it is the first year without observations of it since 1927.

Comet Comas Sola was observed on April 14 at Bergedorf, when its magnitude was 13; a few days earlier J. Stobbe described it as a diffused coma 1′ in diameter. Professor G. van Biesbroeck observed both it and

*Table of*

| Comet | $T$ | $\omega$ | $\Omega$ | $i$ | $q$ |
|---|---|---|---|---|---|
| | G.M.T. | ° ′ ″ | ° ′ ″ | ° ′ ″ | |
| 1905 III | 1905 Apr. 4·04518 | 358 12 21 | 157 25 53 | 40 12 39 | 1·11464 |
| 1921 I | 1921 May 4·85344 | 97 25 31 | 66 4 42 | 22 20 5 | 1·11570 |
| 1923 III | 1923 Nov. 17·84807 | 255 19 59 | 226 39 57 | 113 47 53 | 0·77783 |
| | U.T. | | | | |
| 1925 I | 1925 Apr. 1·51116 | 36 11 40 | 318 3 42 | 100 0 57 | 1·10959 |
| 1930 I | 1930 Jan. 15·60991 | 325 4 45 | 147 33 14 | 99 53 28 | 1·08711 |
| 1930 II | 1930 Jan. 22·30954 | 157 29 44 | 179 0 4 | 124 31 36 | 0·67229 |
| 1932 X | 1932 Dec. 30·53031 | 327 20 27 | 77 40 16 | 24 30 5 | 1·13079 |
| 1933 IV | 1933 Aug. 1·096 | 190 26 17 | 188 33 56 | 10 12 53 | 2·49542 |
| 1935 *d* | 1936 May 12·21366 | 45 2 13 | 299 39 56 | 66 6 8 | 4·03934 |
| 1936 *a* | 1936 July 8·96191 | 148 28 33 | 134 2 47 | 78 33 42 | 1·09990 |
| 1936 *b* | 1936 July 15·84294 | 45 54 13 | 264 10 25 | 121 56 47 | 0·51826 |
| 1936 *c* | 1936 Oct. 3·23616 | 197 14 4 | 164 16 4 | 13 7 57 | 1·45598 |
| 1936 *c* | 1936 Oct. 3·445 | 197 20 32 | 164 14 23 | 13 16 31 | 1·46211 |

Comet Schwassmann-Wachmann (2) till May ; he also recovered his own comet, 1935 *d*, on its emergence from conjunction with the Sun, and deduced an improved orbit.

Comet 1936 *a* was discovered by Mr. L. Peltier, of Delphos, Ohio ; it is his fifth cometary discovery, though his special work is not comet hunting, but the study of variable stars. The new comet was of magnitude $9\frac{1}{2}$ ; its declination was $73\frac{1}{2}°$ N., and as its motion was slow, it remained for some weeks a circumpolar object. It was approaching both Sun and Earth, and the brightness and length of tail increased steadily. The least distance from the Earth was 15 million miles, the comet being then of the second magnitude and clearly visible to the naked eye in the immediate neighbourhood of the full Moon ; there was a conspicuous tail at least two degrees long. The comet was followed by southern observers down to S. decl. 70°, so that it passed nearly from pole to pole. The orbit does not differ greatly from a parabola ; Dr. Davidson found a period of 1769 years.

Comet 1936 *b* had three independent discoverers: Mr. Kaho found it in Japan on July 17 ; it was a diffused object with a tail less than 1° in length, of magnitude 5 or 6 ; it was in Leo Minor, the motion at first being slow northward. The other discoverers were Mr. Lis at Mt. Lubomirs on July 17, and Mr. Kosik at Aschkabad on July 19. Professor van Biesbroeck followed it at Yerkes Observatory till October 24, when it was extremely faint. It passed perihelion just before discovery ; its perihelion distance was half a unit and its inclination 122°. M. Quénisset observed it at Juvisy on July 18 ; he gave its magnitude between 4 and 5, the brightness exceeding that of Comet Peltier on the same night ; its tail was at least 2° long.

*Comet Orbits*

| Period | Equinox | Computer | Reference | Comet | Name |
|---|---|---|---|---|---|
| $226^{y}\cdot20$ | 1905·0 | S. Szeligowski | *Viertel. Ast. Ges.* 1935 | 1905 III | Giacobini |
| $67^{y}\cdot011$ | 1921·0 | H. Hirose | *Observatory*, Aug. 1936 | 1921 I | Dubiago |
| Parabola | 1923·0 | S. Kanda | *Observatory*, Aug. 1936 | 1923 III | Dubiago-Bernard |
| *e* 1·000629 | 1925·0 | L. Orkisz | *Viertel. Ast. Ges.*, 1935 | 1925 I | Orkisz |
| $14028^{y}$ | 1930·0 | F. Koebcke | *Viertel. Ast. Ges.*, 1935 | 1930 I | Schwassmann-Wachmann Peltier-Viertel. |
| $15072^{y}$ | 1930·0 | E. Tillman | *Viertel. Ast. Ges.*, 1935 | 1930 II | Wilk |
| $262^{y}\cdot052$ | 1933·0 | A. D. Maxwell | *U.A.I. Circ.*, 570 | 1932 X | Dodwell-Forbes |
| $7^{y}\cdot48602$ | 1933·0 | A. D. Maxwell | *Michigan Publ.*, 6 | 1933 IV | Whipple |
| *e* 1·003525 | 1936·0 | G. van Biesbroeck | *Harvard Card*, 367 | 1936 | van Biesbroeck |
| $1769^{y}$ | 1936·0 | M. Davidson | *U.A.I. Circ.*, 625 | 1936 | Peltier |
| Parabola | 1936·0 | A. D. Maxwell H. R. J. Grosch | *Harvard Card*, 387 | 1936 | Kaho-Kosik-Lis |
| $8^{y}\cdot06363$ | 1936·0 | C. Jackson | *U.A.I. Circ.*, 629 | 1936 | Jackson-Neujmin |
| $8^{y}\cdot5315$ | 1936·0 | L. E. Cunningham | *Harvard Card*, 401 | 1936 | Jackson-Neujmin |

Comet 1936*c* had two independent discoverers: Mr. Jackson found it at Johannesburg on Sept. 20, and Professor G. Neujmin at Simeis on September 21 ; both observers gave the magnitude as 12. The comet was in Aquarius, in S. decl. 13°, and was moving slowly to S.E. The comet was recorded on Johannesburg plates of September 15, and M. Rigaux of Uccle found a prediscovery image on a plate of September 9.

The comet proved to be a short-period one, belonging to the Jupiter group ; but as the observed arc extended over only five weeks, the period is not yet accurately known, the two latest determinations differing by 0·47 year. Mr. L. E. Cunningham has undertaken a definitive orbit. Suggestion has been made of possible identity with Comet 1895 II (L. Swift), for which a period of 7·2 years was found, but it was not seen again. Identity would only be possible if there have been large perturbations in the interim ; but that is not improbable, as both orbits approach that of Jupiter.

Towards the end of 1936 Professor van Biesbroeck searched for Comets d'Arrest and Tuttle-Giacobini, but without success. This is the second successive return at which d'Arrest has been missed.

A table of cometary orbits published during the year appears on previous two pages. A. C. D. C.

## *Solar Activity*

*Sunspots.*—The Sun's activity appears to have entered generally upon the maximum phase of the present 11-year cycle, although the peak may not be reached for at least another year, 1937–38. Sunspots and faculæ and the various phenomena visible in *Hα* and in H and K are now never absent from the Sun's disc and have been of frequent occurrence in the active zones. The increasing frequency of bright *Hα* eruptions associated with sunspots may be remarked.

The mean daily area of sunspots has increased from 624 millionths of the Sun's visible hemisphere in 1935 to about 1200 millionths in 1936. The mean daily number of groups has increased from $3\frac{1}{2}$ in 1935 to about 8 in 1936. At times no fewer than twelve or fourteen groups have been visible together. During the year twenty large groups of maximum area 500 millionths of the hemisphere or greater have been recorded. Five of these had a maximum area of at least 1000 millionths and are given below with their respective times of central meridan passage and their latitudes:

| | | | |
|---|---|---|---|
| Jan. 7·8 | +27° | Nov. 29·3 | +17° |
| Jan. 19·8 | −32° | Nov. 29·4 | −11° |
| | | Dec. 2·2 | −14° |

The last three, occurring on the disk together, were easily seen with the naked eye for a few days.

During the period of rising solar activity after a minimum in 1933·8 the activity of the southern hemisphere has been further advanced than that in the northern, although latterly the difference has become less marked. At

the total solar eclipse of 1936 June 19 it was remarked that the corona in the southern hemisphere differed from that in the northern and tended towards maximum type, whilst that of the northern hemisphere tended towards minimum type (*Journal B.A.A.*, **46**, 317 ; **47**, 41, 1936).

The lists of bright *Hα* eruptions published by M. d'Azambuja in the Zürich *Bulletin* show that 434 were observed in the twelve months 1935 July 1 to 1936 June 30 ; about 80 per cent. of these were of minor extent. A subtabulation in the *Bulletin* shows their association with individual groups of sunspots, some of which—not always the largest—had more than 20 eruptions recorded during their respective transits of the disc. These eruptions may possibly prove a useful new index for assessing the activity of sunspot groups, and their observation is of importance in view of a possible relationship existing between their occurrence and sudden simultaneous fadings recorded on short-wave wireless transmission (*P.A.S.P.*, **48**, 278, 298, 1936 ; *Nature*, **138**, 1017, 1936 ; *Journal B.A.A.*, Dec. 1936).

Besides the observation of bright eruptions, spectrohelioscopes have also been used during the year at some observatories for measuring radial velocities of dark hydrogen filaments. Occasional velocities in the line of sight of 100 km./sec. shown by dark markings associated with bright eruptions have been recorded during the year, and one velocity of over − 300 km./sec. was measured at Greenwich on December 22 at $10^h\ 12^m$ U.T.

During 1936, 9 small magnetic storms (ranges in D $\geqslant 30'$ or in H or V $\geqslant 150\,\gamma$) were recorded at the Greenwich magnetic station at Abinger as compared with 8 during 1935. Of these 9 magnetic disturbances 4 occurred within four days of the central meridian passage of one or more of the 20 large sunspots recorded above. H. W. N.

*Prominences*, 1936.—There has been a large percentage increase in all forms of prominence activity over that of 1935. The mean daily areas and numbers of calcium prominences as derived from Kodaikanal spectroheliograms are as follows :—

*Areas*

| | North | South | Total |
|---|---|---|---|
| 1936 January to June ... ... ... | 3·44 | 3·57 | 7·01 sq. mins. |
| July to December ... ... | 3·86 | 3·50 | 7·36 „ |

*Numbers*

| | North | South | Total |
|---|---|---|---|
| 1936 January to June ... ... ... | 6·91 | 7·03 | 13·94 |
| July to December ... ... | 7·96 | 7·76 | 15·72 |

Calcium areas and numbers show an increase of 50 per cent. and 9 per cent., respectively, over the previous year. The activity is almost equally divided between the northern and southern hemispheres. The distribution of areas and numbers in latitude is irregular except for a well-marked peak

near 60°. This peak has advanced nearly 10° towards the poles from its position in 1935, and the peak in the southern hemisphere is 5° nearer the Pole than in the northern hemisphere. Greater activity than in 1935 was observed in the equatorial belts, *i.e.* from 0° to 20° latitude.

During 1936, 64 metallic prominences were observed as against 20 in the previous year. Of these, 22 were observed in the northern hemisphere and 42 in the southern hemisphere between the latitudes 6° and 60°. Displacements of the hydrogen line in the chromosphere and prominences observed during the year with the spectroscope numbered 407 as against 174 in 1935. Of these, 204 were towards the red, 175 towards the violet and 28 both ways simultaneously.

Bright reversals and displacements of the $H\alpha$ line observed with the spectroscope on the disc in the neighbourhood of sunspots also show a great increase over the previous year. Bright reversals numbered 745 as against 369 in 1935. The displacements observed numbered 99 as against 28 in the previous year. Of these, 49 were towards the red, 22 towards the violet and 28 both ways simultaneously. $D_3$ was observed as a dark line on 734 occasions as against 303 in the previous year.

Using the Hale spectrohelioscope, 197 displacements were observed in prominences, almost equally divided between the northern and southern hemispheres. Of these, 105 were observed on the east limb and 92 on the west. Displacements to the red numbered 101 and those to the violet numbered 96. The largest displacement in prominences observed in 1936 amounted to 2·6 A.

The mean daily areas of prominences projected on the disc as hydrogen absorption markings amounted to 8973 millionths of the Sun's visible hemisphere as against 4447 in the previous year, showing an increase of 102 per cent. Their distribution in latitude is similar to that of calcium prominences, but the peaks of activity are more emphasised in the case of $H\alpha$ areas than in calcium prominences, so that the activity in absorption markings is confined to a broad belt near 30° and a narrow belt near 60°.

T. R.

### *Stellar Spectroscopy*

*Early-Type Stars.*—Measures of total absorptions in O–B type stars have been made by E. G. Williams (*Ap. J.*, **83**, 279) and by P. Rudnick (*ibid.*, 439). The former gives total intensities (expressed in equivalent widths) for all measurable lines in 84 stars over the region 3820–4922 A. In addition line depths are given for the *H* and *He* lines, for which it was also found possible to obtain reliable contours. These appear to be exponential in form, except in *n* stars where the centres are rather blunt. Rudnick used a microphotometer with a square diaphragm large enough to cover the entire line, and used settings on the clear film as an intermediary in comparing readings given by a line with adjacent portions of the continuous spectrum. He gives total absorptions for all the stronger lines in 70 stars, and discusses the results in relation to Harvard type and absolute

magnitude class. His results in the main appear to agree very well with those of Williams.

E. G. Williams (*Ap. J.*, **83**, 305) has discussed the classification of B-type stars on the basis of his intensity measures referred to above. He prefers the use of ratios rather than absolute intensities, and proposes five such ratios for the purpose. In each of these the intensities of lines (of several different elements) which increase in strength with decreasing temperature are added together and divided by the sum of the intensities of lines of atoms which behave in the opposite way. He also uses the ratios *He/H* (total intensities) and *He/H* (depths). The classification is linked to that of the H.D. system, but includes all the intermediate subdivisions. The author also discusses luminosity effects (using interstellar *Ca* as a criterion of distance), and by combining his measured spectral type with the luminosity group (giant, intermediate or dwarf) he deduces individual absolute magnitudes for most of the 78 stars of his list.

The spectra of 14 B–A-type stars have been measured by Swings and Désirant (*Ap. J.*, **83**, 31) in the near ultra-violet region (3570–3930 A.). Wave-lengths, estimated intensities and identifications are given for 86 lines in B-type stars and 196 in A-type stars. The behaviour of the different elements is also discussed.

Hynek (*Ap. J.*, **83**, 476) has discussed the luminosity difference between *n* and *s* stars of type A. He finds that the *n* stars have an approximately constant absolute magnitude over all sub-types, while the *s* stars show the usual correlation of type and luminosity. The observed luminosity difference between *n* and *s* stars, which has been used for determining spectroscopic parallaxes, is attributed chiefly to this preferential luminosity of rotating stars and partly to systematic errors in classification. The absolute magnitude effect of rapid rotation (through the decreased surface gravity) is shown theoretically to be too small to be observed.

*Late-Type Stars.*—The possibility of using the blue extension as a criterion of luminosity in faint red stars has been investigated by O. J. Lee and others (*Ann. Dearborn Obs.*, **4**, 73). They use five grades of intensity to express this extension, which, when combined with accurate spectral classifications, give absolute magnitudes showing a good correlation with Mount Wilson spectroscopic values. The effect of atmospheric absorption is shown to be small.

Hacker (*Ap. J.*, **83**, 140) gives a critical summary of the results of his measures of lines in the spectrum of Arcturus (mentioned in these notes last year). Lines of 28 atomic and 5 molecular spectra are definitely identified, with others possibly present. The majority of the unidentified lines coincide with unidentified solar lines, especially those found in spot spectra. Only about 30 unblended lines of moderate strength remain completely unidentified. The spectrum of Arcturus has also been investigated by R. W. Shaw (*Ap. J.*, **83**, 225), who has continued his series of studies of stellar spectra in the ultra-violet with aluminium-coated reflectors. The region measured is 3150–3950 A., in which about 330 lines have been measured and identified.

*Bright-Line Stars.*—Interesting changes of a rather irregular nature continue to appear in the spectrum of $\gamma$ Cassiopeiæ. Cleminshaw (*Ap. J.*, **83,** 495), who has measured 160 spectrograms taken during the interval 1914–1935, finds a correlation between changes in radial velocity and variations in the $V/R$ intensity ratio. Changes are only doubtfully present in 1914–1928, but in 1929 a slow decrease in velocity commenced, followed in 1932 by a more rapid increase. Lockyer's observations of the $V/R$ ratio are confirmed, and the behaviour of the star is compared with that of $\beta$ Monocerotis. Lockyer (*M.N.*, **96,** 679) has continued his observations and recorded an increased strength in the central absorptions of all the Balmer lines, together with an increase both in strength and sharpness of some of the helium lines (especially 5016 and 4472). This particular combination of changes had previously been noticed as one of the periodic features in the spectrum of $\phi$ Persei. McLaughlin (*Ap. J.*, **84,** 235) has also recorded some recent observations which are in agreement with those of Lockyer. In addition he finds that the radial velocities from *He* and *H* absorption lines, though previously showing differences, are practically identical in spectra taken in 1936.

P Cygni has been the subject of two investigations. Kharadse (*Zs. f. Ap.*, **11,** 304) has examined the purely photographic effect of the presence of an adjacent strong emission line on the measured position of an absorption line. Measured displacements of absorption lines are found to be too great on account of this effect, which varies with the intensities of the emission lines. Approximate values of the necessary corrections are determined and applied to 120 lines in the region 3750–6680 A. The results suggest that the correlation previously found by Struve between radial velocity and line intensity is not real, but simply photographic. The same applies to the suspected relation between radial velocity and wave-length, but Struve's relation between velocity and ionisation potential is confirmed. O. C. Wilson (*Ap. J.*, **84,** 296) has found variations in the spectrum of P Cygni from spectrograms taken at Lick and Mount Wilson. The Balmer lines are composed of three components, one emission and two absorption lines, the two latter showing pronounced variations in relative intensity. Similar variations occur in the helium lines, and it is suggested that they are intimately connected with the magnitude changes found by Kharadse, Nikonov and Kulikovsky (*Obs.*, **59,** 88).

In a detailed study of 25 Orionis, Helen Dodson (*Ap. J.*, **84,** 180) has found variations in velocity (from absorption and emission lines) which are synchronous with changes in the $V/R$ intensity ratio for hydrogen emission. The period of variation decreased during the interval of observation from 1817 to 1075 days, and the amplitude varied irregularly. The $V/R$ changes, as is common in such stars, vary in phase for different members of the Balmer series, $H\delta$, for example, anticipating $H\gamma$ by about 200 days. There is also a phase difference of about 100 days between emission and absorption hydrogen velocities. Most of the observed phenomena can be interpreted in terms of McLaughlin's model, with the exception of helium absorption, which is conspicuously out of phase with hydrogen.

A similar correlation between changes in radial velocity and $V/R$ ratio (from violet and red edges of single emission lines) has been found for $\chi$ Ophiuchi by Cleminshaw (*Ap. J.*, **83**, 487), with a suggested period of about 10 years. The helium-line variations, as in the last-mentioned star, are out of phase with the hydrogen, and there is an interesting difference in velocity between the singlets and triplets of helium.

Lockyer (*M.N.*, **96**, 230) has found changes in $H\beta$ (central absorption and emission), and in some absorption lines of *Fe*II, *Si*II and *Ca*II in the spectrum of $\zeta$ Tauri. He has also (*M.N.*, **96**, 480) investigated changes in the $V/R$ ratio in $\pi$ Aquarii during the years 1928–1936. There appear to be definite though rather irregular variations, with a mean period of about 1087 days. At times the emission lines completely disappeared.

*Interstellar Matter.*—Seares (*Proc. N.A.Sc.*, **22**, 327) has investigated the colours of stars of photographic magnitudes 10–13·5 in thirty selected areas. His results strengthen the evidence for the widespread presence of selective absorption in space, but the colour-excess seems to be subject to the restriction of an upper limit of about one magnitude. A correlation is suggested between the mean colour-excess of stars in a field and the surface density of extra-galactic nebulæ.

The possibility of obscuring matter existing in the vicinity of the solar system has been examined by Corlin (*Zs. f. Ap.*, **11**, 221). By using parallaxes of stars from Schlesinger's catalogue combined with spectroscopic absolute magnitudes, and (independently) mean reduced parallaxes obtained from proper motions, he has been led to the conclusion that there is a definite obscuration of light in the vicinity of the solar system, particularly in the direction of the centre of the local cluster.

Merrill (*Pub. A.S.P.*, **48**, 179) has confirmed the interstellar origin of two unidentified stellar lines at 5780 and 6784 A. D. L. E.

## *Variable Stars*

The present account, which is intended to be complete till the end of 1936, is arranged as follows: (1) General publications on variable stars, (2) Observational material, (3) Statistical work, etc., (4) Instrumental, (5) Theory, (6) Eclipsing variables, (7) Cepheid variables, (8) Long-period variables, (9) Irregular variables.

The listing of observational material is strictly confined to papers actually published in 1936. As far as papers of more general bearing are concerned, these are also included if written in 1935, but became available too late to be referred to in last year's Council Report.

1. *General Publications.*—The fundamental work on the history and bibliography of all variable stars by R. Prager has been continued. Following the lines of the first volume, referred to in last year's account (*M.N.*, **96**, 357, 1936), vol. **2**, has now been published in *Veröff. Sternw. Berlin-Babelsberg*, 1936. It presents in great completeness the data for 1564 variable stars in the 29 constellations from Cygnus to Ophiuchus, and thus forms

the basis of most of the study in this field. The work is reviewed in *Pop. Astr.*, **44**, 581, 1936.

The *Katalog u. Ephemeriden veränderlicher Sterne für* 1937, the former volumes of which were also published by Prager, appears under the editorship of H. Schneller in *Kl. Veröff. Berlin-Babelsberg*, No. 16, 1936.

This catalogue lists 6968 confirmed variable stars : 23 per cent. of them are long-period variables, 4 per cent. of the δ Cep- and ζ Gem-type, 9 per cent. of the RR Lyr-type, and 13 per cent. eclipsing binaries. For 19 per cent. of the stars the kind of variation could not be stated, and for the same number the type is given but no elements are yet available. For 2600 of the stars, *i.e.* for 38 per cent., the variations are of unknown type. The eclipsing variables divide into 71 per cent. Algol-, 11 per cent. β Lyr-, 11 per cent. WUMa-stars, and the remaining 7 per cent. are not yet accurately classified.

H. Schneller publishes corrections to this catalogue, and that of 1936, in *A.N.*, **258**, 416, 1936, and *A.N.*, **261**, 215, 1936.

T. Banachiewicz' useful ephemerides of eclipsing binaries for 1937 are published as No. 15 of the Rocznik Astronomiczny Observatory, Cracow.

Two new lists of nomenclature appeared in 1936 : In *A.N.*, **258**, 161, 1936, P. Guthnick and R. Prager give definitive names to 550, and in *A.N.*, **260**, 393, 1936, to 193 variables.

E. Zinner has continued his interest in suspected stars in *A.N.*, **258**, 316, 1936. In *A.N.*, **260**, 17, 1936, he gives a catalogue of 478 "missing stars," and asks that more attention be paid to this group. Suspected stars are also discussed by K. Graf Ferrari in *A.N.*, **259**, 85, 1936.

The activity in variable star work during the past year showed again a considerable increase. Nearly all countries have contributed, as is proved by the sources of the references given below.

In this section only a selection of the papers will be mentioned, which deal with the organisation and the wide extent of the variable star work recently initiated in the U.S.S.R. : W. Zessewitsch gives an account in *Pop. Astr.*, **44**, 101, 1936. In *Engelhardt Observatory Bull.*, No. 8, p. 28, P. P. Parenago gives reports of the different commissions. B. W. Kukarkin describes the work at the Sternberg State Astronomical Institute, S. I. Beljawsky that at the Simeis Observatory. A "Plan of investigation of unstudied Variable Stars" was issued by the "Central Bureau for Variable Star investigation in U.S.S.R." by the Sternberg Astr. Institute in Moscow and comprises about 2250 stars.

Variable star workers will find of special interest the relevant parts in *Transactions of the International Astronomical Union*, vol. 5, where A. A. Nijland on pp. 168 and 336 presents the reports and various recommendations of Commission 27, Variable Stars, discussed at the Paris Meeting of the I.A.U.

2. *Observational Material.*—Of the more comprehensive collections comprising data obtained, and the observers' organisations responsible for them, we have first to mention the Notes from the American Association of Variable Star Observers, published by Leon Campbell in *Popular*

*Astronomy*, vol. **44**, pp. 34, 97, 160, 207, 272, 338, 394, 453, 495, 554, 1936. In *Harv. Ann.*, **104**, 1, 1936, H. Shapley points out that the steady increase in the amount of contributed work makes it impractical to continue to carry the tables of observations in an astronomical journal, and that, therefore, vol. **104** of the *Harvard Annals* will be reserved exclusively for the publication of data contributed by members of the Association. The tens of thousands of observations published hitherto in *Harv. Ann.*, **104**, Nos. 1 and 2, pp. 1–57, 1936, indeed symbolise effectively, as Shapley says, the mutual benefits of wide scientific co-operation.

The French observers publish in *Bulletin de l'Association française d'observateurs d'étoiles variables*, vol. **4**, 1936, observations made in 1935 of long-period variables averaging more than 2000 observations of over 150 stars monthly. J. Dufay and H. Grouiller describe the methods employed at the Lyon Observatory (*Congrès des Sociétés savantes, sect. d. sciences*, **68**, 13, 1935).

The Variable Star Section of the British Astronomical Association has collected as hitherto the numerous observations of their active members. In *J.B.A.A.*, **46**, 182, 1936, W. M. Lindley discusses several thousand observations of long-period variables.

In the *A.N.*, where most of the German, Danish, Italian, etc., observations are published, we note especially the long list of discoveries made by C. Hoffmeister, *A.N.*, **259**, 37, 1936, recording 604 new variables. His collaborator O. Morgenroth, in *A.N.*, **258**, 265, 1936, and *A.N.*, **261**, 261, 1936, gives 23 and 42 new variable stars.

From the southern hemisphere long lists of new discoveries were also published, especially that of W. J. Luyten in *A.N.*, **258**, 121, 1936 (his ninth list, containing 269 stars); C. Hoffmeister compiles (*A.N.*, **258**, 39, 1936) 71 new southern variables.

Elis Strömgren for the Copenhagen Observatory communicates in Publ. No. 104, *A.N.*, 1936, etc. the results obtained by the members of the active Astronomisk Selskab.

Concerning the Russian material, we note here the remarks by A. A. Nijland in *Transact. I.A.U.*, **5**, 169, 1936. Of longer lists published we mention, *e.g.*, S. I. Beljawsky's note on 62 variables discovered on Simeis plates (*Veränderliche Sterne*, V**2**, No. 50, 36, 1936).

A report on the work done by the variable star section of the Astronomical Society of South Africa for 1934–1935 is given in the *Journal* of this Society, vol. **6**, 41, 1935.

The members of the Astr. Soc. of Japan have published numerous results in the *Mem. Astr. Soc. Japan*, vol. **5**, Nos. 1, 2.

The Commission for Variable Stars of the Astronomical Society of China publishes its vol. **6**, 1936, through the *Obs. Univ. Sun Yatsen, Canton.*

Special photo-electric work was done throughout the year at several observatories. Amongst the results published we note the studies made at the Lick Observatory of $\delta$ Scu (*L.O.B.*, **17**, 175, 1935) and of $\epsilon$ Lyr (*P.A.*, **44**, 308, 1936), both by E. A. Fath. E. J. Meyer gives in *A.N.*, **259**, 237, 1936, an account of his work on $\gamma$ UMi.

All other results obtained, and not mentioned in the foregoing remarks or in § 3–10, are presented in an abbreviated form in the following paragraphs of this section, § 2, the investigators being arranged in alphabetical order :—

H. L. Alden, *A.J.*, **45**, 62, 1936, ZZ Cru; L. B. Andrews, *Harv. Bull.*, 902, BS Agr.

I. Balász, *A.N.*, **258**, 305, VZ Her, and *A.N.*, **261**, 129, RR Leo; S. Beljawsky, *Nishni Nowgorod-Veränderliche Sterne*, V3, 97; M. Beyer, *A.N.*, **258**, 273, 1936, 11 ecl. var., 2 Cepheids, and *A.N.*, **260**, 12, ecl. var. 432, 1928 Tau; J. van der Bilt, *Journ. Obs. Marseille*, **19**, 41, X Gem, and **19**, 133 R Leo, Y Mon; S. Blažko, *Ver. Sterne*, V2, 50, XX Cyg, and V3, 97, Z Dra; V. Bodokia, *Ver. Sterne*, V3, ZZ Per; K. Bohlin, *A.N.*, **260**, 286, AA Aql; N. Bougoslavski, *Ver. Sterne*, V3, 86, XZ Cyg; P. P. Bruna, *B.A.N.*, **7**, 339, new var. in Cen.

M. Chang Yuin, *Obs. Univ. Sun Yatsen, Canton* (**6**, 107, TX Cyg, and 7, No. 1, SV Per, and 7, No. 2, diff. var.; D. O'Connell, *A.N.*, **260**, 400, 14 new var.; and *Riverview Coll. Obs. Publ.*, No. **2**, 19, 5 Cepheids.

R. S. Dugan, *A.J.*, **45**, 70, ecl. var.; W. Dziewulski, *Bull. Wilno*, vol. **1**, No. 17, GO Cyg.

V. Ehl, *A.N.*, **259**, 328, ST Cam; J. Ellsworth, *Bull de l'assoc. française d'observateurs d'étoiles variables*, **4**, 133, U Del, and **4**, 185, RY Per, and **4**, 188, S Cnc; M. Esch, *A.N.*, **261**, 8, 6 new var.

C. Fedtke, *A.N.*, **258**, 378, 60, 1933 Aur; N. Florja, *Veränd. Sterne*, V2, 55, RR Lyr series; M. G. Fracastoro, *Mem. della Soc. Astr. Italiana*, **9**, No. 2, 169, and *Mem. Oss. Arcetri*, No. 54, 3, δ Lib.

I. Gadomski, *Circ. Warsaw*, No. 16, RW Tau, X Tri; S. Gaposchkin, *Harv. Bull.* 903, 27, W Her, TZ Her, UY Her; S. Gesundheit, *A.N.*, **261**, 263, new Algolstar; H. Gitz, *Ver. Sterne*, V3, 65, 4 new var.; K. Graff, *A.N.*, **261**, 151, CY Aqr; J. L. Greenstein, *Harv. Bull.* 901, var. in Messier 3; I. Th. Groosmuller, *Hemel en Dampkring*, **34**, 197, CY Aqr.

E. Hertzsprung, *B.A.N.*, **7**, 333, AP Vel, and *B.A.N.*, **8**, 25, RZ Vel, SW Vel, SX Vel; A. van Hoof, *B.A.N.*, **261**, 72, AN Vel, AM Pup, V 343 Cen, and *B.A.N.*, **261**, 74, AE Pup and 3 long-period var.; L. Jacchia, *Mem. Soc. Astr. Ital.*, **9**, 147, BL Her, EZ Lyr, and *A.N.*, **261**, 211, diff. var.; F. Kepiński, Circular No. 626 *I.A.U.*, BD 39°·4114. F. Kepiński and M. Kowalczewski, *Acta Astr. Cracow*, sér. c, **2**, 127, SU Dra; F. Koebcke, *Publ. Obs. Poznań* II, **4**, 4, SU Dra; W. Krat, *Act. Astr.*, c, **2**, 129, RT Lac; C. Krebs, *A.N.*, **261**, 109, diff. var.; W. Krug, *A.N.*, **259**, 15, SY UMa; W. E. Kruytbosch, *B.A.N.*, **8**, 1, 20 var.; B. W. Kukarkin, *Ver. Sterne*, V2, 59, ST CVn; A. Kwieck, *At. A.*, c, **2**, 137, and *Publ. Obs. Poznań* II, **4**, 31, 8 Algolstars.

K. Lassowsky, *A.N.*, **254**, 93, KR Cyg; F. Lause, *A.N.*, **258**, 311, ecl. var.; also *A.N.*, **259**, 189 and **259**, 384, ecl. var., and **260**, 289, 20 ecl. var.; W. O'Leary, *Riverview Coll. Obs. Publ.*, No. 2, 31, long-period var., and *A.N.*, **260**, 400, 14 new var., and *Riverview Coll. Obs. Publ.*, No. 2, 17, Cepheid, and No. **2**, 29, 2 ecl. var.; I. N. Lehmann-Balanowskaja, *Pulk. Circ.*, No. 16, 31; E. Loreta, *Bul. Ass. Fr. Et. Var.*, **5**, 9, TT Cyg, ST UMa, TX Dra,

R Cam, and in *l'Astronomie*, **50**, 46, and *A.N.*, **260**, 412, V Del, and *A.N.*, **261**, 120, ST Her, and *A.N.*, **261**, 263, AB Cyg.

D. J. Martinoff, *Engelhardt Obs. Bull.*, No. 7, 3, RX Dra ; J. Mergentaler, *Contr. Obs. Lwów*, No. 5, 3, 11 new var. and SX, KY, KZ, LM, LP Cen ; G. R. Miczaika, *A.N.*, **258**, 11, RS CrB, and *A.N.*, **258**, 247, W Cyg, and *A.N.*, **258**, 410, TW And, SV Cam, and *A.N.*, **258**, 349, 6 var., and *A.N.*, **259**, 143, X Her, and *A.N.*, **261**, 10, VX Cyg, VY Cyg, and *A.N.*, **261**, 67, 15 var., and *A.N.*, **261**, 225, new var., and *A.N.*, **261**, 227, TY Del, and *A.N.*, **261**, 229, 4 long-period var. ; P. Muller, *Journ. Obs. Marseille*, **18**, 177, $\theta$ Her.

J. J. Nassau, *A.J.*, **45**, 138, AR Aur ; S. V. Nekrasova, *Engelhardt Obs. Bull.*, No. 7, 9, 9 var. ; and No. 7, 18, AN And, AP And, $\beta$ Aur, and *Acta Astr. Cracow*, c, **2**, 129, RT Lac, and *Veränd. Sterne*, V**2**, 42, new var., and V**2**, 45, LO, CN, MR Cyg, and V**3**, 66, 5 var. ; A. V. Nielsen and *Astronomisk Selskab, Meddelser Kobenhavn*, No. 108, diff. var., and *A.N.*, **259**, 53, 1936, **260**, 377, **260**, 419, 261, 8, **261**, 271, diff. var., and *Medd. fra Ole Romer Obs. Aarhus*, No. 7, 49, 1936, CE Her ; A. A. Nijland, *Proc. R. Ac. Amsterdam*, **39**, 176, RZ Pers, and **39**, 509, R CVn, and *A.N.*, **259**, 69, long-period var., and *A.N.*, **259**, 79, SS Cyg.

C. P. Olivier, *P.A.*, **44**, 257, ecl. var., P. Th. Oosterhoff, *B.A.N.*, **8**, 29, RZ Vel, SW Vel, SX Vel, and **8**, 34, ecl. var. in *N.G.C.* 3532, and **8**, 41, XX Vir, and **8**, 44, VV Pup, and **8**, 45, YZ Tau, and **8**, 48, BK Cen.

I. Pagaczewski, *Publ. Obs. Poznań* II, 4, 43, and *Acta Astr.*, c, **2**, 149, RW Cet, VV Eri ; P. P. Parenago, *Engelhardt Obs. Bull.*, No. 8, 37, RY Cas, U Aql. ; H. N. Pedersen, *A.N.*, **260**, 11, diff. var. ; F. Pingsdorf, *A.N.*, **259**, 399, ER Car. S. Piotrowski, *Acta Astr.*, c, **2**, 132, 2 var., and c, **2**, 154, and *Bull. Obs. Belgrade*, **1**, 9, DK Cyg, BB Peg. L. Plaut, *B.A.N.*, **8**, 51, W UMa ; R. Prager, *B.A.N.*, **8**, 49, long-period var., and **8**, 50, 2 Algolstars.

R. Rajehl, *Publ. Inst. Astr. Charles Univ.*, Prague II, No. 18, diff. var. ; P. M. Ryves, *A.N.*, **261**, 8, 6 new var.

H. Schneller, *A.N.*, **259**, 12, CY Aqr. ; M. Schwarzschild, *B.A.N.*, **7**, 337, BB Cen ; G. Selivanov, *Tashkent Circ.*, 48–50, diff. var., and *A.N.*, **258**, 205, 743 ; 1933, Oph., and *Veränd. Sterne*, V**2**, 42, 3 new var., and V**2**, 49, $\alpha$ UMi, and V**3**, 89, 4 RR Lyr stars ; A. Soloviev, *Veränd. Sterne*, V**3**, 77, 18 RR Lyr stars, and V**3**, 97, 3 long-period var., and *Tadjik Circ.*, Nos. 16–18, 36 RR Lyr stars, etc., and No. 19, 6 new ecl. var., and No. 20, BE Mon, 4 var., and *A.N.*, **260**, 286, diff. var., and *A.N.*, **261**, 215, star 669. 1936 Vir.

J. Uitterdijk, *B.A.N.*, **8**, 61, double star with two variable components, and **8**, 62, 2 Algolstars, and **8**, 66, semiregular var., and **7**, 338, 2 new var. ; A. A. Wachmann, *A.N.*, **258**, 361, SS Lac, and **259**, 323, CM Lac ; A. S. Williams, *M.N.*, **96**, 553, YZ And ; F. W. Wright, *A.J.*, **45**, 70, ecl. var., BD −2. 4840.

W. Zessewitsch, *Tadjik Circ.*, No. 15, $\mu$ Cep, ST Pup, 185, 1935, Peg, T Sex ; E. Zinner, *A.N.*, **261**, 104, TW Vir ; W. Zonn, *A.N.*, **258**, 120, 974, 1935 Cyg, and *Acta Astr.*, c, **3**, 15, FI Ori, and *Bull. Wilno* I, No. 17, 12, CO Lac, and No. 17, 19, 17 new variables ; A. van Zutphen, comparison stars for U Cyg, *B.A.N.*, **8**, 58, 1936.

3. *Statistical Work, etc.*—H. Shapley gives in *Proc. Nat. Acad.*, **22**, 8, 1936, an interesting "Summary of investigations of variable stars." He points out that much variable star work contributes only to knowledge of the individual stars, but that several of the investigations in progress at Harvard are designed to make use of stellar variation as an instrument in the attack on problems of a more general nature. In such researches emphasis is placed either on extensive surveys that aim at providing material suitable for analysis of type frequency, luminosities and distances, and in space distribution, also on peculiar types and variable stars of anomalous behaviour.

In his summary Shapley discusses the discovery and distribution of a thousand new variables in the Small Magellanic Cloud; 2·5 per cent. of all the stars of the cloud, to magnitude 16·8, are variable stars, and presumably almost wholly of the Cepheid class. The number available for a further study of the period-luminosity relation is now more than 200, and new light is thrown on the form of the curve for super-giant Cepheids, etc. Much progress has been made in the investigation of Milky Way variable stars. The use of the wealth of material obtained in the different fields in mapping out galactic distances and structures must be supplemented by corrections for space absorption through studies of other kinds. In some regions, however, such as MWF 233 (see last year's report, *M.N.*, **96**, 359, 1936), the variable stars could be used successfully and without correction as distance indicators, since extragalactic nebulæ appear on the plates in considerable numbers.

One of the richest variable star fields on record is MWF 193, not far from the galactic centre in Sagittarius. Up to the magnitude limit 16·5 the field shows about 10 variables per square degree. Extensive studies are concerned with the variable stars in high galactic latitude, resulting in hundreds of new discoveries, of which 38 per cent. belong to the cluster-type class of Cepheids, 23 per cent. are eclipsing variables, 0·4 per cent. classical Cepheids, 12·3 per cent. long-period variables, 12·3 per cent. irregular variables, and 14 per cent. for which the periods or types are still unknown.

Three important papers published in 1936 supplement the systematic survey of two of these fields. Shapley, in *Harv. Circ.* 411, studying the distribution of more than 700 galaxies in MWF 233, finds a very small general absorption coefficient in this "low latitude window in the south-eastern Milky Way." In a neighbouring region on the galactic circle no galaxies are recorded, and the general absorption may there be more than three times as great. In *Harv. Bull.* 90, 207, 1936, Miss H. H. Swope examines this field as well as MWF 187 on a similar basis, giving catalogues of 146 and 423 variables respectively, and investigating their different types. The survey has been continued by a new series of plates by J. S. Paraskevopoulos and Miss W. Boyd, and a preliminary discussion is published by H. Shapley in *Harv. Bull.* 904, 1. It is found that 100 of the newly discovered cluster-type Cepheids are clearly on the other side of the galactic centre, the distance of which is assumed to be of the order of 10 kiloparsecs. The 5 most distant variables appear to lie 23 kiloparsecs from the Sun when projected on a line through the galactic centre.

Other papers related to statistics of variables in the Milky Way are due to Miss Hoffleit, who examines new variables in MWF 105, 108, 111 (*Harv. Bull.* 901, 20), and in MWF 239 (*Harv. Bull.* 902, 13). A catalogue of 100 new variables in MWF 16 is given by E. Hughes Boyce in *Harv. Bull.* 903, 28. N. W. McLeod investigates those found in MWF 133.

A statistical note by M. S. Zverev should be mentioned (*Engelhardt Obs. Bull.*, No. 8, 34, 1936, dealing with variable stars in a field in Lyra).

W. Baade has discovered an interesting variable of cluster-type, *P.A.S.P.*, **48**, 274, 1936, whose distance from the galactic plane, 30 kiloparsecs, is the largest on record, while the distance from the centre of the galaxy, 34 kiloparsecs, is surpassed only by two globular clusters.

4. *Instrumental.*—A new red sensitive photo-electric photometer is described by J. S. Hall (*Ap. J.*, **84**, 369, 1936), who used it at the Sproul Observatory for extensive infra-red photometry of 285 Ko stars. S. Gaposchkin has in *Harv. Bull.* 902, 22, continued his programme with the automatic multiple exposure cameras, and has investigated RR Gem, period $0^d.397$. Observations of this star, covering thirty-four years, cannot be represented by a linear system of elements. H. Grouiller, in *Bull. Ass. Fr. Et. Var.*, **4**, 109, 1935, deals with filter observations of variable stars. In *Engelhardt Obs. Bull.*, No. 8, 34, work is mentioned done by P. P. Parenago on systematic errors arising from colour differences, and by W. W. Scharonov (see also *Veränd. Sterne*, V**3**, 68) on a method to check the Purkinje effect in the observations of variable stars.

5. *Theory.*—The problem of investigating how much of the fluctuations found in variable star observations are to be regarded as real is the subject of an interesting paper by K. Walter in *A.N.*, **259**, 205, 1936. A study of the eclipsing variable VW Cep serves as illustration of his formulæ.

The same author introduces, in *Z. f. Aph.*, **12**, 203, 1936, some changes in method for the determination of ellipticity in the case of the eclipsing variables of W UMa-type. His examples, the systems VW Cep and RR Cen, apparently show near maximum a short-lived physical brightening of about $0^m.04$, which is perhaps caused by an additional radiation from the regions where the components are nearly in contact. V. Zessewitsch, in *Publ. Obs. Leningrad*, **6**, 46, 1936, deals with tables for the determination of the orbits of Algol stars using the hypothesis of limb darkening. Reports on the methods of determining orbits and absolute elements of eclipsing binaries are given by N. I. Tschudowitschev in *Engelhardt Obs. Bull.*, No. 8, 30, and by B. W. Kukarkin, No. 8, 31, 1936.

Further remarks on the theory of eclipsing variables are made by Th. Banachiewicz in *Publ. of the Polish Academy.*, No. 3, 3, 1936, with reference to the developments of Russell and Shapley, Fetlaar, etc. J. Ellsworth generalises a method given by Harting (*Publ. Obs. Lyon*, I, 2, 1, 1936; *Congrès des Soc. Sav., Sect. des Sc.*, **68**, 17, 1935). In *A.N.*, **258**, 393, 1936, we find an investigation by Z. Kopal, dealing with the physical meaning of the periodic correction terms to elements of eclipsing variables. Finally, W. Krat, in *Astron. Journ. of the U.S.S.R.*, **13**, 527, 1936, offers new suggestions for the determination of the orbital elements.

In a paper on the diameters of the stars, E. A. Kreiken, *A.N.*, **259**, 349, 1936, considers the distribution of a number of eclipsing variables. J. Ellsworth, in *C.R.*, **201**, 540, 1935, is concerned with the asymmetry of the light curves of eclipsing variables attributable to a tidal effect, and refers to the systems U Cep and RZ Cas.

Z. Kopal discusses in *M.N.*, **96**, 854, 1936, the internal constitution of eclipsing binaries. He concludes that the density concentration depends on the age of the system : The components of a "new-born binary" appear to be nearly homogeneous ; then the concentration of both components increases, and approaches at the end of the evolution the model requiring a high density concentration. The main sequence shows an increase of the concentration with advancing spectral type. The problem offered by apsidal motion in close binary systems and the internal constitution of stars is dealt with critically in a note by W. Krat in *Engelhardt Obs. Bull.*, No. 8, 32. E. A. Kreiken, supplementing his earlier papers, deals with the fission theory of the eclipsing variables in *Z. f. Aph.*, **11**, 323, 1936, and gives formulæ for the period of axial rotation and orbital revolution in binary systems.

Turning next to the theoretical progress made in the study of the Cepheids, we note an important paper published by M. Schwarzschild. In *Z. f. Aph.*, **11**, 152, 1935, he presents an extensive investigation of the pulsation theory, and concludes that, if deviations from black-body radiation are taken into account, the observed monochromatic amplitudes appear in agreement with the pulsation theory. His analysis includes also the problem of the relation in phase between light- and radial-velocity curves.

Other interesting work was done by H. A. Kluyver, who in *B.A.N.*, **7**, 313, 1936, deals with the extension of the theory of adiabatic Cepheid pulsation, investigating terms of higher order ; E. Vandekerkhove, in a paper in *Comptes rendus du 2e Congrès national des Sciences*, p. 272, 1935, discusses the application of some formulæ to the study of Cepheids. A. E. H. Bleksley (*A.N.*, **260**, 161, 1936) enquires whether the Cepheids radiate as black bodies, and arrives at the conclusion that they do so very closely over the whole spectral range hitherto investigated. The same author publishes in *A.N.*, **260**, 165, 1936, a note on the variation of radius and temperature in Cepheids, and compares his theory with the observational material obtained by H. Kox in *A.N.*, **256**, 21, 1935.

B. W. Kukarkin contributes a series of interesting papers. An investigation of his in *Russ. Astr. Journ.*, **13**, 103, 1936, on atmospheric pulsation of Cepheids, and theories of stellar variability emphasises the necessity of distinguishing definitely between changes occurring within the chromosphere and photosphere of the star. In *Veranderliche Sterne*, V3, 42, 1936, he studies the systematic shift with phase of visual and photographic light curves of long-period Cepheids ; in V3, 70, 1936, and V3, 73, 1936, he discusses the relation between light and radial velocity amplitudes. In *Observatory*, **59**, 87, 1936, he deals with the distribution of these stars according to periods and with the absorption of light in the galactic plane. Comparison of light and velocity curves of Cepheids by means of harmonic

analysis is proposed by V. B. Balasoglo in *Engelhardt Obs. Bull.*, No. 8, 31, 1936.

The pulsation theory of Mira Ceti is fully discussed by J. Gabovitš in *Publ. Obs. Tartu*, vol. 29, No. 3, 1936; in vol. 28, No. 5, 1936, the same author deals with related problems.

6. *Eclipsing Variables.*—Very intensive work has been done in furthering the study of the eclipsing type. The systematic observing programme, already mentioned in *M.N.*, **96**, 361, 1936, was the subject of two notes by D. J. Martinoff in *Engelhardt Obs. Bull.*, No. 5, 3, 1936; No. 8, 29, 1936. The latter of these gives also a report by S. N. Korytnikov on a bibliography of the eclipsing stars.

The study of light variation of eclipsing variables in different wave-length regions was further developed by J. Hellerich in *A.N.*, **261**, 121, 1936. In his Heidelberg thesis, published in *A.N.*, **261**, 235, 1936, K. Himpel investigates 34 eclipsing variables in three wave-lengths in an attempt to clarify the problems of the law of limb darkening, of the position of the second component in the Russell-diagram, and of the small differences in time between the moments of mid-eclipse for different wave-lengths.

R. O. Redman presents in *M.N.*, **96**, 488, 1936, a contribution on the problem of the centre to limb variation in Fraunhofer line intensities. This is the first attempt that has been made to study the variation of spectrum across the disc of a star. Spectrographic material of the Algolstars U Cep and U Sge during eclipse obtained by the author at the Dominion Astrophysical Observatory at Victoria was used. Redman succeeded in disentangling the spectra of the two components, and thus was able to deduce the appearance of the spectrum coming from the uneclipsed portions of the primary disc alone. The photometry of the total intensities showed in the case of U Cep, type Ao, that the Balmer lines of hydrogen behave as though they vanish at the limb of the primary, while in U Sge, type B9, there is a definite fall in intensity from centre to limb, though less than in the case of U Cep. For fainter lines, H and K, the present accuracy of the measures does not allow definite conclusions to be drawn. But the importance of obtaining observations of lines other than those of hydrogen is stressed in a further note by Redman in *Observatory*, **59**, 287, 1936. He indicates the complications which may arise through the presence of Stark effect.

The case of U Cep is also studied at the Yerkes Observatory by H. O. Rosenberg, who in *Ap. J.*, **83**, 67, 1936, describes a method which made it possible to derive colour indices for two different wave-lengths from simultaneous exposures on one plate in the focal plane of a Newtonian reflector. He finds $1^{m}.5$ as the total change in colour index for U Cep between the phase of constant light and of primary minimum, and attributes the greater part of this to the spectral difference between the components (Ao, G6). Individual light curves in different wave-lengths reveal an effect of darkening at the limb, which increases with decreasing wave-length and is similar to that observed in the Sun.

The great interest in the system of $\zeta$ Aur recorded in last year's report, *M.N.*, **96**, 360, 1936, has continued. In addition to the complete list of

papers given there, we must mention first D. H. Menzel's theoretical work on the structure of the atmosphere, *Harv. Circ.* 417, 1936, in which he investigates the extinction produced by an ionised atmosphere ; he recommends a careful study of the K-star spectrum also outside of eclipse. K. Himpel, *A.N.*, **258**, 251, 1936, discusses the 1934 eclipse on the basis of his filter observations. V. Kozlow and N. Florja discuss in *Astron. Journ. of the U.S.S.R.*, **13**, 509, 1936, a method for investigating the mass and density of the atmosphere of the K5-component ; their numerical results contain the absorption coefficient of the atmosphere, the value of which they regard as still undeterminable. Further notes appeared in *Veränd. Sterne*, V3, 75, 1936, by W. Krat, in *Journ. Obs. Marseille*, **18**, 176, 1935, by R. Tremblot, in *Cælum*, **6**, 174, 1936, in *Publ. Obs. Univ. Sun-Yatsen*, **6**, 133, 1935. Many problems related with this star have been left for future eclipses, the next of which begins 1937 April 21·5 and ends 1937 May 30·6, the uncertainty being only about $\pm 1^d$ (whereas it was $\pm 14^d$ in the 1932 prediction of the 1934 eclipse).

The eclipsing system *u* Her was dealt with in two papers : W. Krat in *Z. f. Aph.*, **11**, 71, 1935, studies the intensity distribution in the spectrum, using 222 plates, and finds that the ellipticity of the components and the reflection effect depends on the wave-length. A new reduction of the photometric material at present available is given by G. R. Miczaika and W. Kentmann in *A.N.*, **261**, 205, 1936.

M. Beyer presents in *A.N.*, **258**, 273, 1936, a valuable new series of discussions of 11 short-period variables of eclipsing type extending over many years. It contains, *e.g.*, the star VV Cas, for which R. F. Sanford in *Ap. J.*, **79**, 84, 1934, found a spectroscopic period of $8^d·52$ and a mass function 3·7, which suggests one of the greatest known values for the mass of the system. Beyer's photometric discussion discloses some difficulties, variations of very small amplitude, and other irregularities.

Absolute elements of eclipsing variables, combining spectroscopic and photometric orbits, have been determined by J. J. Nassau for AR Aur in *A.J.*, **45**, 137, 1936 ; see also the spectroscopic results by A. B. Wyse in *P.A.S.P.*, **48**, p. 24, and **131**, 1936. A similar case is TX Leo treated by O. Mohler in *Publ. Roslyn House Obs.*, No. 2, 1936.

In *Veröff Berlin-Babelsberg*, **11**, H. 3, 1936, M. Güssow publishes a photometric discussion of the interesting variable $\epsilon$ Aur, for which 13800 observations of 47 observers between 1842 and 1934 are available. The author arrives at the conclusion that the period is $9888^d$, the duration of the eclipse $714^d$, that of light increase and decrease $192^d$, that of minimum $330^d$ and the photo-electric amplitude $0^m·8$. According to these data a picture is described in which a massive bright cF5-star is eclipsed every 27 years by a dark companion, which possibly is a giant of very low temperature, and is surrounded by a wide extended atmosphere. It is similar to the case of $\zeta$ Aur in that this atmosphere is transparent to the light of the F5-star during eclipse. Rotation of the dark component and its atmosphere is made responsible for the observed anomalies of the absorption lines, which were revealed especially in the fundamental work by

E. B. Frost, O. Struve, C. T. Elvey in *Publ. Yerkes Obs.*, vol. 7, pt. 2, 1932. Discrepancies and small variations in brightness and radial velocity remain, indicating some physical occurrence in the atmosphere. Mention may also be made of another paper on $\epsilon$ Aur, published by W. Krat in *Engelhardt Obs. Bull.*, No. 7, 15, 1936. A. Danjon publishes new photometric observations of this star in *Journ. Obs. Marseille*, **19**, 209, 1936.

S. Gaposchkin (*Harv. Bull.* 902, 17, 1936), using a large number of Harvard plates, succeeds in showing that the spectroscopic binary 29 CMa is a variable of eclipsing type, with two almost equal minima. Gaposchkin's complete set of elements places this system amongst those of special interest. The larger component with a mass of 40 $\odot$ represents the most massive star known among eclipsing variables.

Two eclipsing stars of unusually long period, 13·5 and 18 years, are reported by Miss Swope in *Harv. Bull.* 902, 6, these periods are exceeded only by the 27-year period for $\epsilon$ Aur just mentioned.

The prototype of a significant class of eclipsing binaries, W UMa, is investigated by W. A. Calder in *Harv. Bull.*, 903, 15, 1936, who discusses his accurate photo-electric observations of secondary minima on two consecutive nights; the one of the observed minima appeared to be about $0^{m}\cdot04$ deeper and about 6 minutes wider than the other.

Calder (*Harv. Bull.* 904, 7, 1936) also undertook a photo-electric study of the massive system BD $+6^{\circ}\cdot1309$, *i.e.* "Plaskett's star." He draws attention to the probable existence of real variations, the nature of which he was unable to determine though the changes do not seem to fit the spectroscopic period of 14·41 days.

7. *Cepheid Variables.*—A careful spectrophotometric study of $\delta$ Cep by W. Becker appears in *Z. f. Aph.*, **13**, 69, 1936. He represents the intensity distribution relative to the comparison star $\epsilon$ Cep by two gradients in different wave-length region. In his red region the amplitude is only 75 per cent. of that in the blue. Colour temperatures and amplitudes on different scales are given, and disturbances in the intensity distribution during two periods discussed, etc.; finally, amplitudes are calculated from the temperature variation according to Planck's law, and are found to exceed these observed by about twice. H. Brück and W. Strohmeier publish in *Z. f. Aph.*, **13**, 1, 1936, a spectrophotometric investigation of the Cepheid variable S Sge; they derive monochromatic light curves, colour indices, gradients, temperatures and their changes with phase.

The shapes of the light curves of long-period Cepheids is dealt with by P. P. Parenago and B. W. Kukarkin in an article in *Z. f. Aph.*, **11**, 337, 1936. They deny the existence of real variations in shape, and form more than a hundred "normal curves" through combination of all available single mean curves. Statistical discussion of this material leads to relations between periods, asymmetry, phase, area of the humps, etc. A dependance of shape and period is emphasised, as well as a break of some characteristics for periods of 9 days. The authors suggest that there may be two kinds of light variation in these stars, dominant for $P$ greater or less than $9^{d}$, respectively.

D. O'Connell notes irregularities in the light variation of some Cepheids in *Riverview Coll. Obs. Publ.*, No. 2, 28, 1936.

In *M.N.*, **96**, 258, 1936, W. M. Smart suspects $\beta$ C Mi of being a Cepheid of very short period, discussing W. A. Calder's photo-electric Harvard observations, and applying corrections for extinction ; see also *Observatory*, **59**, 32, 1936. Calder discusses this question in *Observatory*, **59**, 227, 1936, but does not support this interpretation of his measures.

The spectroscopic binary Boss 5442 presents a very interesting case. Its period is $3^d{\cdot}31$ (R. K. Young, *Publ. Dom. Aph. Obs. Victoria*, **1**, 319, 1921). A preliminary note by P. Guthnick in *A.N.*, **261**, 217, 1936, refers to the results of 600 photo-electric observations, which show that the star is not an eclipsing variable, as suggested previously, but of $\delta$ Cep-type ; and that surprisingly its period is not equal to that spectroscopically determined, but to $1^d{\cdot}13$, *i.e.* $0^d{\cdot}025$ more than one-third of it. The light variation itself is not always periodic, but shows a peculiar behaviour, differing perhaps from that of the radial velocity.

8. *Long-period Variables.*—An important publication is contributed by S. A. Mitchell, H. L. Alden, etc. (*Publ. Leander McCormick Obs.*, vol. **6**, 1935). This gives 306 pages of observations of long-period variables, magnitudes and comparison stars ; see also *Journ. Roy. Astr. Soc. Canada*, **30**, 105, 1935.

A contribution to the systematic study of Mira variables is presented by M. Beyer in *A.N.*, **259**, 101, 1936, who discusses 2100 new observations of 42 stars.

P. W. Merrill (*Ap. J.*, **83**, 272, 1936) investigates low-dispersion spectra of 12 faint long-period variables at various phases of their light curves, and arrives at very interesting conclusions : The continuous spectra of Me-variables are remarkably strong between $\lambda$ 4226 and H ; the intensities of the dark H and K lines differ widely in different variables ; large changes in total light may occur without marked changes in the absorption spectrum ; both the bright hydrogen lines and $\lambda$ 4202, 4308, 4521 change in the systematic manner outlined in *Ap. J.*, **71**, 285, 1930. Some of these stars do not have observable anomalous "companion" spectra at minimum, as do o Cet and R Aqr. In $\chi$ Cyg interesting spectral peculiarities have been discovered. In *Pop. Astr.*, **44**, 62, 1936, the same author gives the eighth and last article of his interesting series on long-period variable stars and the stellar system.

The excitation of certain emission lines in spectra of long-period variables is studied in a preliminary note in *P.A.S.P.*, **48**, 331, 1936, by A. D. Thackeray and P. W. Merrill. Among the lines becoming conspicuous during the light decrease, only certain lines of an iron multiplet appear. It is suggested that two unobservable lines of *Mg*II may play the rôle of the exciting radiation, the idea leading to a fluorescence mechanism similar to that offered by Bowen for nebulæ.

Infra-red photometry of 30 long-period variables is presented by C. Hetzler in *Ap. J.*, **83**, 372, 1936. He developed a photographic method of relative exposure times at the Allegheny and Yerkes Observatories to give

consistent results in obtaining magnitude curves at $\lambda$ 8500, and partly also at $\lambda$ 9500. Relative shapes and magnitude ranges (mean $2^m.4$ as compared with $5^m.0$ visually), infra-red indices at maximum (mean $3^m.9$), and at minimum, $6^m.4$, are given. A persistence of the infra-red maximum after the visual curve has declined is noted in some cases, *e.g.* in *o* Cet, which star is the subject of a more detailed discussion.

H. Grouiller discusses (*Observatory*, **59**, 86, 1936) the Purkinje phenomenon in long-period variables, etc., at minimum, especially with reference to an article by A. D. Thackeray (*Observatory*, **58**, 285, 1935). In *Bull. Ass. Fr. Et. Var.*, **4**, 138, 1936, he deals with the same question, whereas in *Congrès des Soc. Sav., Sect. des Sc.*, **68**, 33, 1936, he is concerned with the general scheme of observing long-period stars. Statistical investigations of the Me-Variables are to be found in *Publ. Oss. Astr. della R. Univ. Bologna*, **3**, 19, 1934, by L. Jacchia.

9. *Irregular Variables.*—C. Payne-Gaposchkin studies the spectroscopic characteristics of the R Coronæ type (*Harv. Bull.* 903, 35, 1936). On the basis of the light variations the author lists only 7 stars as belonging definitely to this group : R CrB, type c Goep ; UW Cen, K ; S Apo, R3 ; RS Tel, R 8 ; WX CrA, R 5. Investigating the spectra, it is pointed out that an abnormally great abundance of carbon seems to characterise the atmospheres of these stars, which thus constitute the only known group of variables for which such a regularity of spectrum has been found.

The last minimum of R CrB is described by F. Lause in *A.N.*, **260**, 86, 1936. R CrB, SS Aur, U Gem, R Scu are discussed by W. M. Lindley in *J.B.A.A.*, **46**, 182, 1936. A star, probably of the R Coronæ type, is WX CrA, which, exhibiting an R5 spectrum, is the subject of a note in *Harv. Bull.* 902, 11, 1936. L. Campbell gives, in *Harv. Circ.* 407, 1935, the light curves of 12 peculiar variables.

An interesting case of peculiar variability is that of XY Per, which is dealt with by C. D. Boyd in *Harv. Bull.* 904, 18, 1936. This star, a visual binary of $1''.4$ separation with A-type spectrum at its maximum of $10^m.5$, shows an irregular light curve, which may be explained on the assumption that both components of the visual double are variables, perhaps of Algol type, whose minima occasionally coincide.

The RV Tauri-Variables are considered by A. A. Ilinič in *Pulk. Obs. Circ.*, No. 15, 40, 1935, who points out that the radial velocity curves of V Vul and R Sge are closely related with their light curves, as are those of classical Cepheids. S. Gaposchkin investigates the case of UU Her in *Harv. Bull.* 903, 23, 1936, on the basis of more than 800 observations from 1923 to 1934. He finds a behaviour during the last six years like an RV Tauri variable, though in the previous years it was of a different character, thus being an "intermittently regular variable."

In conclusion, we must mention the work done on $\gamma$ Cassiopeiæ. In 1936 the brightness of this star underwent an unprecedented increase, and the interest which it had occasioned during recent years owing to its variable spectrum has, therefore, become greatly enhanced.

Several of the new investigations of $\gamma$ Cas are concerned with its spectro-

scopic history. In *Ap. J.*, **83**, 495, 1936, C. H. Cleminshaw discusses 160 plates taken between 1914 and 1935 at Michigan. It is shown that prior to 1928 no undoubted variation in velocity or in emission ratio could be established. Systematic changes began in 1929, when the hydrogen emission ratio and the velocities of *H* and *Fe*II began to decrease. In 1932 the rate of change increased; at the end of 1933 the violet component was twice as strong as the red, and the velocity had increased by 20 km./sec. In 1934 the lines first appeared narrow and single; but at the end of that year both components were showing again, although the red one was now three times as strong as the violet, and the velocity correspondingly decreased. Cleminshaw mentions some similarity with the Be-star $\beta$ Mon; see also his paper on $\chi$ Oph in *Ap. J.*, **83**, 487, 1936.

W. J. S. Lockyer studied the variability of the spectrum of $\gamma$ Cas in the interval between 1935 October and 1936 April in his fifth paper on the star (*M.N.*, **96**, 679, 1936). He draws special attention to the resemblance between the behaviour of the helium and hydrogen lines in $\gamma$ Cas and in $\phi$ Per. This latter star was recently treated in a special monograph by H. C. Schiefer, *Ap. J.*, **84**, 568, 1936.

The spectral changes of $\gamma$ Cas since March 1935 are described also by D. B. McLaughlin in *Ap. J.*, **84**, 235, 1936. The helium lines developed strong, sharp absorptions, with distinct emission borders; simultaneously, the central absorption of the hydrogen lines exhibited a marked strengthening. McLaughlin remarks that the changes suggest the formation of a more extensive outer shell of absorbing gases by the process of outward streaming of atoms, a hypothesis which accords with the fact that the red emission components were the stronger during these changes.

The surprising variations in the magnitude of $\gamma$ Cas have been announced since October 1936 by E. Strömgren in *Copenhagen I.A.U. Circ.*, Nos. 625, 627, 630, 631. According to them, F. de Roy noted that the brightness of $\gamma$ Cas in the period covered by 230 Harvard photometric measures from 1879–1901 probably did not vary at all; the year 1894 is perhaps an exception, the star being then $2^m.28$ on November 6, reaching $1^m.67$ on November 29, and coming back to normal $2^m.26$ on December 5. On 1936 March 14 L. Jacchia found the star almost equal to $\alpha$ Per, $1^m.9$. According to a communication to the Variable Star Section of the B.A.A., R. Rigolet noticed the first signs of a light increase of the order of $0^m.2$ in July. According to I. Baize (*L'Astronomie*, **50**, 395, 1936, *I.A.U. Circ.* 627) the star was $1^m.85$ on August 5, remained about $1^m.8$ during September, and brightened up to $1^m.6$ during the first half of October. In *Harv. A.C.*, No. 392, N. T. Bobrovnikoff reports the brightness on October 5 as being $1^m.6$. The star has since remained bright; minor fluctuations were present. Short notes on the interesting light and spectral behaviour were further published in *Hemel en Dampkring*, **34**, 369, 1936, by de Kock, in *Cœlum*, **6**, 220, 1936, by L. Jacchia, in *C.R.*, **203**, 362, 1936, by D. Chalonge, in *Pop. Astr.*, **44**, 495, 1936, by L. Campbell. A. B.

*Novæ*

The year 1936 will always be remembered as an exceptional one in the history of the discovery of new stars. No less than four bright novæ were found in the second half of the past year. Nova Herculis 1934 still remained an object of regular observation and extensive discussion. The year brought also the first success in the systematic search for super-novæ, which was initiated seven years ago at Mount Wilson, and now resulted in a discovery of great importance. In addition, related problems, such as the peculiar behaviour of P Cygni (and that of $\gamma$ Cassiopeiæ which is dealt with in the Council Note on Variable Stars, § 9), have attracted great attention. As a result an unusually large number of publications has appeared, testifying to the greatly enhanced interest in the nova problem, and attacking it in the most diverse ways.

The present report aims at completeness up to the end of 1936. It continues last year's accounts in *M.N.*, **96**, 373, 1936, on Nova Herculis 1934, and *M.N.*, **96**, 364, 1936, on previous new stars, etc., and comprises the following sections: (1) General work; (2) N. Per 1901; (3) N. Aql 1918; (4) Faint new-discovered novæ; (5) N. Her 1934; (6) N. Lac 1936; (7) N. Aql 1936, No. 1; (8) N. Sgr 1936; (9) N. Aql 1936, No. 2; (10) P Cyg; (11) Super-Novæ.

1. *General Work.*—A classification of novæ is given by B. P. Gerasimovič in *Pop. Astr.*, **44**, 78, 1936; see also *Pulk. Circ.*, No. 16, 5, 1936. He subdivides all "normal novæ" into two main classes according to their light curves (the classification of which he regards as representing the different types of nova outburst): (I) Slow novæ, (II) Flashing novæ. These two classes comprise 5 and 3 subclasses, respectively: Ia, Permanent novæ (P Cyg); Ib, semi-permanent ($\eta$ Car); Ic, Slow novæ proper (N. Pict 1925); Id, Slow novæ with a sudden fall towards minimum (N. Her 1934). IIa, Flashing novæ proper (N. Aql 1918); IIb, Flashing novæ exhibiting very rapid fall with subsequent partial recovery (N. CrB 1866).

B. Vorontsov-Velyaminov's book *New Stars and Galactic Nebulæ* (312 pp., Moscow, 1935) is discussed by S. Gaposchkin in *Pop. Astr.*, **44**, 115, 1936, and by S. Chandrasekhar in *Observatory*, **59**, 95, 1936, who mentions that a French translation is under way. A general account of the subject of novæ was given by H. Spencer Jones in *J.B.A.A.*, **46**, No. 1; see also *Observatory*, **58**, 371, 1935.

Theoretical considerations were published by Sch. B. Gordeladse, *Z. f. Aph.*, **13**, 48, 1936, dealing with the conditions of the application of the Zanstra method to derive the temperature of stars surrounded by a comparatively small gaseous envelope, like Be-stars, Wolf-Rayet-stars, Novæ, etc. The author argues that the temperatures obtained must be too high. Another theoretical paper concerned with stars of this type is an interesting note by B. P. Gerasimovič on the radiation-pressure in an expanding envelope, published in *M.N.*, **96**, 574, 1936.

J. C. Boyce, *M.N.*, **96**, 696, 1936, lists the observations of forbidden lines in a paper which proves especially useful for identification purposes in novæ spectra in their nebular stage.

The relation found by E. G. Williams connecting the intensity of the interstellar K-line with the absolute and apparent brightness was applied by O. C. Wilson in *P.A.S.P.*, **48**, 229, 1936, to former novæ. He derives for N. Aql 1918 an absolute magnitude at maximum of $-9^{m}.9$, and for N. Cyg 1920 the value $-7^{m}.9$. S. Gaposchkin discusses in *Harv. Bull.* 901 the absolute magnitudes and parallaxes of six novæ, using results of his previous investigation in *Harv. Bull.* 899. P. Rossier (*Publ. Obs. Geneva*, A. 31, 4, 331, 1936) is concerned with the calculation of the initial radii of new stars.

In an interesting paper in *A.J.*, **45**, 145, 1936, D. B. McLaughlin derives dimensions and parallaxes of 6 novæ, the basis being the following assumptions. The observed radial velocity represents the rate of expansion; the effective temperature can be deduced from the spectral type; the luminosity of the nova at and before maximum is determined by the same formula which relates radius and temperature in a normal star. If the first assumption is valid we are justified in using in addition to this equation another one, which represents the integrated velocity curve, and in this way McLaughlin arrives at his results. The validity of this assumption is discussed in a paper by A. Beer in *M.N.*, **97**, 231, 1937, where it is shown, using increased observational material that in reality we have to deal with two "active surfaces" of the nova, the one of which leads to temperature and brightness and corresponds to the photosphere, whereas the expansion of the other alone produces the radial velocity changes. Thus two different kinds of radii for the novæ are obtained.

A special study of the early spectra of six novæ is made by McLaughlin in *Ap. J.*, **84**, 104, 1936. He states that lines of neutral oxygen occurred in three absorption systems of N. Gem 1912, in at least two systems of N. Aql. 1918 and N. Oph 1919, in at least one system of N. Cyg 1920, and in at least three systems of N. Her 1934. Nova Pist 1925 showed no evidence of *O*I. He finds that the lines of neutral carbon occurred in possibly two absorption systems of N. Gem, in one of N. Aql and N. Oph, in two of N. Her, whilst they are suspected in N. Cyg. McLaughlin concludes that strong lines of *O*I and *C*I constitute a typical peculiarity of the spectra of novæ in their early stages.

An interesting account of the results obtained up to 1936 November for N. Her, N. Lac, N. Aql No. 1, N. Sgr, N. Aql No. 2, is due to A. B. Wyse in *P.A.S.P.*, **48**, 302, 1936.

W. H. Steavenson has continued his extensive light observations of former novæ. His report in *M.N.*, **96**, 698, 1936, on the results obtained in 1935–36 includes 11 such stars. N. Vul 1670: Further remarks are made, in addition to those in *M.N.*, **95**, 78, 1934, regarding Harvard estimates and those made by the author; N. Oph 1848: The slight variability, with a range of about $0^{m}.6$, as observed in previous years persists; N. Cyg 1876: Variability $0^{m}.4$ as in former years; N. Aur 1891: No change; N. Per 1901: Observations on 92 nights show its usual marked variability, the range amounting to $1^{m}.9$; N. Lac 1910: Seems to fade slowly; N. Gem 1912: No change; N. Aql 1918: No change; N. Lyr 1919: Perhaps slightly variable; N. Cyg 1920: No change; N. Aql 1925: No change observed.

2. *Nova Persei* 1901.—In *Annals, Solar Physics Observatory, Cambridge*, vol. **4**, pt. 2, 1936, F. J. M. Stratton discusses 45 slit spectra secured at Cambridge and 7 at Yerkes, and compares his results with the other material available for this and for other novæ. In addition to the usual displaced $\alpha$ Cygni-type absorption, evidence is offered for a weak undisplaced $\alpha$ Cygni-spectrum. The structure of the complex bright bands in the nebular stage is found to agree fairly closely with that in the initial stage. W. H. Steavenson's recent photometric observations of this star have just been mentioned. Numerous measures, made since 1933, are published also by B. M. Peek in *M.N.*, **96**, 703, 1936.

3. *Nova Aquilæ* 1918.—E. S. Pearson publishes an important monograph on N. Aql 1918 in *Ann., Sol. Phys. Obs.*, **4**, pt. 3, 1936. His work is based on 44 plates, obtained by J. S. Plaskett at Victoria, and deals mainly with the development of the band structure. He summarises the detailed results in 14 interesting points on pp. 125–126 ; they form the foundation of the tentative physical explanations of the observed phenomena which he puts forward.

4. *Faint New Novæ.*—The investigation of Milky Way Field 187 by Miss H. H. Swope in *Harv. Ann.*, **90**, 217, 1936, records 6 novæ. Two of them are also subject of a note in *Harv. Bull.* 902, 5, in which Miss Swope points out that the examination of more than a thousand plates taken since 1889 does not show the first star until September 1901, when it reached 9th magnitude. The other, which did not exceed $12^m$, appeared probably in May 1893.

A suspected nova visible on a Wolf-Palisa Chart of Gemini from a plate of 1908, and described by T. Banachiewicz in *Acta Astr.*, c, 2, 144, and c, 3, 15, 1936, has been proved to be a defect in the chart plate by further notes from O. Morgenroth, *A.N.*, **259**, 100, 1936, and M. Mündler, *A.N.*, **259**, 147, 1936.

5. *Nova Herculis* 1934. (A) *Light-history.*—The light-history of N. Her 1934 has been dealt with in numerous papers, some concerned with the discussion of complete light-curves, others giving accounts of observations made continuously throughout the year.

H. C. Wilson bases his light-curve in *Pop. Astr.*, **44**, 20, 1936 on 3400 American observations ; P. Muller in *L'Astronomie*, **50**, 49, 1936 on 5000 estimates. The results obtained by members of the Association Française d'Observateurs d'Étoiles Variables are discussed by H. Grouiller, who publishes a light-curve in *C.R.*, **202**, 465, 1936 ; see also *Publ. Obs. Lyon*, **1**, ser. 1, fasc. 16, and *L'Astronomie*, **50**, 220, 1936. A comparison sequence is given by S. A. Mitchell and C. A. Wirtanen in *A.J.*, **45**, 31, 1935.

Observations of this kind are published in *M.N.*, **96**, 699, 1936, by W. H. Steavenson, in *A.N.*, **258**, 126, 1936, by different observers, in *A.N.*, **259**, 80, 1936, by Norlind, in *Tashkent Circ.*, No. 48, 1935, by Selivanov, in *A.N.*, **259**, 10, 1936, by Vand and Vlček, in *A.N.*, **259**, 243, and *A.N.*, **261**, 149, 1936, by Lause, in *A.N.*, **261**, 276, 1936, by Soloviev, in *Bull. Wilno*, No. 17, 33, 1936, by Dziewulski, in *A.N.*, **259**, 244, 1936, by Miczaika, in *Publ. Lwow*, No. 5, 1936 by Mergentaler, in *Bull. Ass. Astr. du Nord*, **10**, 84, 1936, by Bernson, in *Bull. Ass. Fr. Et. Var.*, **5**, 7, 1936, by Baldet, and by different

observers in *Tadjik Circ.*, Nos, 15, 20, in *A.N.*, **260,** 265, and *A.N.*, **260,** 412, 1936, further by S. Kanda in *Mem. Astr. Soc. Japan*, **5,** No. 1, p. 56, 1936.

In *Harv. Bull.* 903 we find photometric measures made at the Harvard Observatory by Howells, Swan and Baker, and represented by a light-curve. Photometric and colorimetric results are published by J. Ellsworth in *Bull. Ass. Fr. Et.*, **5,** 1, 1936, *Publ. Lyon*, 2, I, 121, 1936, and *C.R.*, 202, 28, 1936. G. C. Flammarion and F. Quenisset publish a note on the colour in *L'Astronomie*, **50,** 1936.

W. E. Bernheimer obtained, at the Arcetri Observatory, a systematic series of the nova fluctuations during autumn 1935 which he discusses in *Mem. della Soc. Astron. Italiana*, ix–4, 339, 1936. In the same volume, p. 201, we find also observations by L. Taffara made at Catania Observatory.

Infra-red photometry on Nova Herculis has been done by C. Hetzler photographically at $\lambda$ 8500 (*Ap. J.*, **83,** 388, 1936), and photo-electric filter observations in the red were obtained by J. S. Hall and R. W. Delaplaine at the Sproul Observatory (*A.J.*, **45,** 197, 1936).

(B) *Duplicity.*—The investigation of the nova as a visual double star has been continued. J. Dick in *A.N.*, **258,** 264, 1936, and G. Simonow in *A.N.*, **259,** 81, 1936, give micrometric measures of the distance of the components, which, according to information from G. Kuiper, had increased to $0''{\cdot}5$ towards the end of the year. A note on this subject appeared by H. Shapley in *Pop. Astr.*, **44,** 211, 1936; see also H. N. Russell, *P.A.S.P.*, **48,** 32, 1936, and R. G. Aitken, *P.A.S.P.*, **48,** 340, 1936.

(C) *Early Spectrum.*—We turn now to the spectroscopic results. The most complete monograph on the first phase which has so far appeared is that by F. J. M. Stratton (*Annals, Solar Physics Observatory, Cambridge*, **4,** Part 4, 1936). He measures and discusses the spectrum in a complete day-to-day series of plates from the morning of discovery till the end of 1934, making use of the Cambridge material, supplemented by the earliest Greenwich spectra, and also by some of those obtained at Edinburgh and Lick. Summarising he states that at discovery on December 13, when the spectrum was of B-type, the radial velocity given by the absorption lines was $-1066$ km./sec. The hydrogen line velocities seem to increase from $-903$ for $H\zeta$ to $-1984$ km./sec. for $H\alpha$. By the evening of the same day the spectrum had changed to A-type, and the velocities had diminished to $-689$ km./sec. By the morning of December 14 the velocities had diminished still further. The line *Mg*II 4481 had then become very prominent, and the spectrum grew daily later in type, as the nova brightened to its maximum. By December 21 the absorption I had decreased to $-173$ km./sec., the hydrogen lines then agreeing with the other elements, while the bright bands had narrowed, and become much less prominent.

After the maximum, December 22, these bands reappeared and widened, and after December 23 a fresh absorption II was visible with a velocity of $-300$ km./sec. Absorption I was last seen on December 26, and II became the principal feature. This spectrum was of a later type than I, and was accompanied from December 24 to 27 by absorption bands of cyanogen, while the star was of a type between F and R. Stratton includes

also a discussion of anomalous absorption velocities observed when the spectrum had become crowded with lines, and mentions the disturbing influence present due to atoms, moving towards the Earth at an angle to the line of sight, which absorb light from other atoms, emitting a line of slightly shorter wave-length, and moving away from the Earth.

(D) *Visual and Ultra-violet Spectrum.*—Discussing the Mount Wilson material in the long wave-length region (in *Ap. J.*, **82**, 413, 1935) P. W. Merrill presents a most valuable contribution to our knowledge of this star. Studies of the spectral history of Nova Herculis are due to N. T. Bobrovnikoff, published as *Contr.*, No. 2, 1935, and No. 4, 1936, of the Perkins Observatory. He concentrates his attention on the visual part of the spectrum. Other investigations of the visual region appeared in *M.N.*, **95**, 544, 1935, by A. Beer; in *Z. f. Aph.*, **10**, 220, 1935, by W. Grotrian and W. Rambauske; in *Pop. Astr.*, **43**, 265 and 328, 1935, by D. B. McLaughlin, and in *Ann. Dearborn Obs.*, **4**, Part 8, 1935, by N. L. Pierce.

The ultra-violet spectrum of Nova Herculis is investigated in *Z. f. Aph.*, **11**, 76, 1936, by B. Meyermann and P. Wellmann, using plates obtained with the Göttingen quartz spectrograph between $\lambda$ 3040 and 3640, in a region, therefore, which was also studied by H. E. Green in *M.N.*, **95**, 694, 1935.

(E) *Spectrophotometry, Temperature.*—W. M. H. Greaves and E. Martin describe in *M.N.*, **96**, 425, 1936, the Greenwich spectrophotometric measurement of Nova Herculis. They obtain the relative distribution of energy in the continuous spectrum of the nova for the spectral regions considered, and further the intensity of the lines, measured in terms of the neighbouring continuous background. By combining these results the relative intensity of the lines in term of $H\alpha$ as unit is deduced, and, further, the absolute intensities of $H\alpha$ are obtained. In *Nature*, **137**, 405, 1936, Greaves compares his conclusions with regard to the continuous spectrum with those of Barbier, Chalonge and Vassy (*C.R.*, **201**, 128, 1935), and Cohn (*Nature*, **137**, 150, 1936); the latter discusses his point again in *Nature*, **138**, 127, 1936.

The colour-temperature of Nova Herculis is investigated by E. G. Williams and H. E. Green in *M.N.*, **96**, 434, 1936. Two principal conclusions are drawn, that the energy distribution is not Planckian, and that the intensity in the ultra-violet is extremely high. The authors compare their results with those of Beileke and Hachenberg in *Z. f. Aph.*, **10**, 366, 1935, and with the just-mentioned work of Barbier, Chalonge and Vassy. Mention must be made of a note by I. A. Balanovsky in *Pulkova Circ.*, No. 16, 1935, on the spectrophotometric study and the cyanogen absorption on 1934 December 24; he obtains 6800° as the corresponding colour temperature. In *Z. f. Aph.*, **12**, 281, 1936, the problem of the nova temperature is also discussed by H. Oehler, who finds differences between his results and that of Beileke and Hachenberg. For the later nebular stage he attempts to derive ionisation temperatures according to the theoretical developments of R. H. Stoy and V. A. Ambarzumian.

F. L. Whipple and C. H. Payne-Gaposchkin give in *Proc. Nat. Acad.*, **22**, 195, 1936, a qualitative interpretation of the main features observed in the

bright bands, and relate them with the two visually observed components of the star. They regard these as two gaseous masses of low density, ejected from the central star, probably very early in the outburst. They point out that the strong absorption lines seen in the early post-maximum stages may be formed at higher levels than the corresponding broad bright lines, in a deep atmosphere built up by the continuous ejection of material from the surface of the original star. It is assumed that it is the latter process that produces the continuous background, while the doubled bright lines arise in the two ejected nebulous masses.

An extensive spectrophotometric study by the same authors was published in *Harv. Circ.*, Nos. 412 and 413. Using 26 Harvard plates taken from 1934 December 14 to 1935 April 6 they derive the energy distribution in the continuous spectrum. It is found that the colour temperature increases with decreasing brightness, and a mean value of 10,000° is given. Intensities of the absorption lines are listed for *H*, *Ca*II, *Fe*II, derived from 47 plates, and for the cyanogen absorptions from 6 plates. In *Harv. Circ.* 413 the theory of continuous ejection is applied to the data of the nova, based especially on its recent developments by S. Chandrasekhar. The authors calculate that a mass of about ten times the Earth was involved in the ejection up to the principal minimum. After this it appears probable that the procedure of continuous ejection ceased to be important. The mass responsible for the observed duplicity of the emissions and for the two visual components is estimated to be larger. It is further stated that the agreement of observation with the predictions of the theory furnishes evidence, that on the average the density of matter at any point in such an atmosphere is proportional to the net outward flux of radiation.

Attention is drawn to an anomalous absorption effect in Nova Herculis by E. G. Williams in *Observatory*, **59**, 331, 1936. He finds completely black absorption lines, the central depth sometimes exceeding the intensity of the continuous spectrum, whereas the preliminary analysis suggests the existence of a residual intensity.

(F) *Nebular Stage.*—W. S. Adams and A. H. Joy discuss in *Ap. J.*, **84**, 14, 1936, the Mount Wilson observations from 1935 April to 1936 February, tabulating displacements, intensities and identifications of the lines. They describe how in April the forbidden lines of *Fe*II became prominent, being displaced by about 30 km./sec. to the violet as compared with the permitted lines. The plates taken in May and later show only minor changes in the intensity and structure of the emission lines in the then fully developed nebular stage.

The spectroscopic material of this time obtained at the Solar Physics Observatory, and at the University Observatory, Cambridge, is the basis of a publication by A. Beer in *M.N.*, **96**, 236, 1936, which results in the identification of about 100 bands between $\lambda$ 3120 and $\lambda$ 6580, attributed to about 30 different atoms.

Further discussions of the nebular stage of Nova Herculis are due to B. Vorontsov-Velyaminov, who, in *Z. f. Aph.*, **11**, 145, 1935, describes the earlier spectra as photographed in Moscow ; to M. Bloch and J. Dufay, who

deal in *C.R.*, **201**, 1463, 1935, with a series of plates obtained at Lyon in 1935 October and November; and in more detail, using their 61 objective-prism plates between 1935 June and 1936 July, in *Z. f. Aph.*, **13**, 36, 1936, giving numerous emission lines and their estimated intensities. A note on the study of the nebular spectrum at the Dom. Astroph. Obs. at Victoria is published by W. E. Harper in *J.R.A.S. Can.*, **30**, 124, 1936.

(G) *Miscellaneous.*—A possible interpretation of the absorption spectrum is discussed by W. W. Morgan in *Ap. f.* **83**, 252, 1936, based on the Yerkes plates. Two velocity systems which he observed in 1935 January yield velocities of +1090 and −850 km./sec. He suggests these may arise from the starlike components ejected from the nova, similar to those observed visually by G. P. Kuiper. In *Pop. Astr.*, **44**, 1936, D. B. McLaughlin gives a historical note concerning the explanation of the nova bands. A. Beer, in *Říše Hvězd-Prague*, **17**, 209, 1936, contributes an account of the developments during the first two years. B. W. Kukarkin publishes in *Engelhardt Obs. Bull.*, No. 8, 33, 1936, an interesting note on N. Her, and on the nova problem in general. He describes in this connection his attempts to study the spectra of the U Geminorum variables, which he assumes to have a common physical cause with novæ.

Other papers on the spectrum not mentioned hitherto are by L. H. Aller, A. H. Mikesell, and D. M. Popper, who publish in *P.A.S.P.*, **47**, 327, 1935, a note on the results obtained at Berkeley; O. Mohler discusses his spectra in *Publ. Roselynhouse Obs.*, No. 1, 1935. Those obtained at Lyon are dealt with by J. Dufay and M. Bloch in *C.R.*, **200**, 217, 1935; *Bull. Soc. Franç. de Physique*, No. 372, 78, 1935; *Congrès des Soc. Savantes, Sect. des Sc.*, **68**, 8, 1935; *Lyon Publ.*, **3**, A. 1, 119, 1936. A note by D. Beloritzky is to be found in *Journ. Obs. Marseille*, **19**, 204, 1936.

H. N. Russell investigates in *P.A.S.P.*, **48**, 29, 1936, the motion of gas seen near N. Her, discussing the suggestion that the steady drop of velocity found for component I in the absorption spectrum (from −250 on December 15 to −170 on December 19) arose from the gravitational attraction of the central star. Under this assumption he derives a formula for the mass of the star, and obtains also a value for the parallax. The inclusion of earlier spectrograms obtained at Greenwich and Cambridge leads F. J. M. Stratton in *Observatory*, **59**, 325, 1936, to a new examination of the situation. He finds a marked variation in the radial velocities with the wave-lengths, a marked difference between the velocities for hydrogen, and for *Fe*II and other ionised elements, and decides that the application of the mass formula leads to improbable high values. In a paper in *Ap. J.*, **85**, 23, 1937, R. Minkowski continues this discussion, considering also other novæ, and suggests—in order to maintain the hypothesis of the thin expanding shell—that the motion of the gas near novæ may not be governed by gravitation and radiation pressure alone, but by some additional force. The observed inward accelerations appear to him much too large to be explained by electrostatic forces; but he obtains reasonable results from calculations on the effect of certain magnetic fields.

6. *Nova Lacertæ*, 1936.—No less than 14 observers could claim to be

independent discoverers of Nova Lacertæ, 1936 (=605, 1936=CP Lac; position $22^h\ 13^m{\cdot}3$, $+55°18'$) on June 18. From nine different countries the discovery was announced nearly simultaneously, a welcome sign of the careful watch now kept on the sky. The star was first seen in Japan, where K. Gomi in Hokkaido found it at $11^h\ 40^m$ U.T., being of magnitude $4^m{\cdot}1$. The western observers on the evening of the same day found the brightness already $3^m{\cdot}5$, and within the next 20 hours the light had increased by $0^m{\cdot}8$. The maximum, about $2^m{\cdot}2$, was reached about June 20·9.

The star faded rapidly and steadily. Nine days after maximum it was fainter than $5^m$, and before the middle of July it became invisible to the naked eye. The $7^m$-limit was passed about August 4, $8^m$ at September 12, $9^m$ at December 2, and by the end of the year the star was already fainter than $9^m{\cdot}2$. The fluctuations so marked in N. Her were here inappreciable.

In the *I.A.U. Circ.*, No. 596, C. Hoffmeister states his opinion that the star on June 18·1 was probably still invisible to the naked eye, as he had surveyed this region carefully without noticing it.

With regard to the earlier pre-discovery history the investigation in *Harv. Bull.* 904, 3, 1936, by D. Hoffleit is of special interest. On 36 plates between 1917–1933 the star is visible, being fainter than $15^m$; a small increase of brightness (1927–28 : $15^m{\cdot}4$, 1930–33 : $15^m{\cdot}1$) seems indicated. A communication by P. Parenago based on the study of Moscow plates is in general agreement with this result (*I.A.U. Circ.* 600), as well as with earlier material, obtained in Bergedorf and elsewhere (*A.N.*, **259**, 340, 1936, etc.).

Those publications, which are mainly concerned with the light-history, are to be found in : *A.N.*, **259**, suppl. to Nos. 6211–17; *A.N.*, **259**, 33 and 355, 1936; *A.N.*, **260**, 6, 92, 228, 439, 1936; *A.N.*, **261**, 63, 137, 141, 277, 1936. See also *I.A.U. Circ.* 595, etc.; *Harv. A.C.* 381, etc. *Observatory*, **59**, 293, 1936, gives a light curve by W. H. Steavenson; another extended till the end of the year is published by M. Beyer in *Jahresbericht*, 1936, *Privat-Sternwarte, Hamburg*, 1936, p. 6, who also gives *A.N.*, **261**, 141, 1936, a uniform comparison sequence with a chart. Further notes are published in *Observatory*, **59**, 235, 1936; *J.B.A.A.*, **46**, 321 and 346, 1936; *Veränd. Sterne*, **5**, 1936; *L'Astronomie*, **50**, 330, 407 and 538, 1936; *Ciel et Terre*, **52**, 216, 1936; *Gazette Astronomique*, **23**, 93, 1936; S. Kanda gives his observations in *Mem. Astro. Soc. of Japan*, **5**, 65, 1936.

Photo-electric series were obtained by W. A. Calder (*Harv. Bull.* 904, 4), with a view to revealing the extent of small fluctuations in the early history; another series of this kind is due to E. J. Meyer, *A.N.*, **261**, 57, 1936, which also includes the maximum.

Some of the spectroscopic observations are also referred to in the publications above, especially those by P. Guthnick in *A.N.*, **259**, 334, 1936, by E. Bianchi in *A.N.*, **259**, 344, 1936, and by M. Beyer in *A.N.*, **259**, 355, 260, 6 and 141, 1936.

Preliminary spectrographic results from the Solar Physics Observatory, Cambridge, are published by T. W. Wormell and J. C. Dobbie in *Nature*, **138**, 38, 1936, and from the Toronto Observatory in *J.R.A.S. Canada*, **30**, 209, 1936, by R. K. Young. The spectrum has also been studied at Marseille,

Meudon, Lyon, Stockholm (*I.A.U. Circ.* 596), etc. A note by D. Beloritzky is to be found in *C.R.*, **203**, 397, 1936. A paper by G. Cecchini and L. Gratton in *Contr. R. Specola Merate*, No. 23, 1936 (see also *Mem. Soc. Astr. Ital.*, **10**, 13, 1936), gives an account of the special variations during the first days after discovery, and lists the measured velocities of hydrogen and *Ca*II, discussing also the interstellar lines of the latter, the colour temperature, the line contours and some related problems.

At the Lick Observatory A. B. Wyse succeeded in obtaining an uninterrupted series of spectra from discovery till the middle of July, and describes his interesting results in *P.A.S.P.*, **48**, 234, 1936. Summarising he says, that N. Lac "has been fairly regular in its irregular behaviour," but that it has established a record for a galactic nova by the tremendous displacements of its absorption lines. His spectra cover the range *Hα* to λ 3200, and the developments observed are described as follows :—

On June 18 and 19 the spectrum was continuous, with absorption lines due to *H*, *Na*, *Ca*II, *Fe*II, etc. The sharp interstellar lines of *Ca*II and $D_1$, $D_2$ were unusually strong. After the nova had passed its maximum emission lines became observable ; those of *H* and *Fe*II were bordered on the violet side by a double set of absorption lines, whereas the absorptions of *Ca*II were much stronger than before, but broad and single. The displacements were for hydrogen as large as −1150 km./sec. on June 18 and increased steadily until in late June the absorptions split into two components. By July 2 the stronger of these had a velocity of −2550 km./sec. and the fainter −2750 km./sec. ; by July 7 both sets of lines had gone.

Already on June 19, however, another set had appeared, with a velocity of −570 km./sec., increasing in two days to −800 km./sec. On June 21 a third strong set of hydrogen absorptions came into being, displaced first by −3000 km./sec., on June 24 by −3350 km./sec., and on June 25 by −3500 km./sec. ; soon afterwards it disappeared. There are many other points of interest noted by Wyse, *e.g.* the peculiar behaviour of certain *N*II-lines, and of the pair λ 4097 and 4103 of *N*III. The latter appeared on July 2, and underwent a series of erratic changes, similar to some observations in previous novæ, especially N. Aql 1918. By June 27 the forbidden lines of *O*I were visible ; by June 28 the line λ 5755 of [*N*II] was observed and became stronger in early July, whilst as early as July 10 [*O*III], typical for the nebular stage, appeared, to strengthen considerably afterwards.

The nebular spectrum is briefly discussed by A. B. Wyse in *P.A.S.P.*, **48**, 303, 1936. By 1936 November the width of the emissions corresponded to a velocity difference of about 3200 km./sec., giving a maximum velocity for the expanding gas of about 1600 km./sec. Two faint maxima are indicated, separated by 1800 km./sec. At this time most of the light appears concentrated in the three nebulium lines of [*O*III]. Then follow, in the order of prominence, hydrogen, λ 5755 [*N*II], λ 4640 *N*III, and lines of [*Ne*III], [*O*I], λ 4686 *He*II. The unidentified bright band at λ 6085 (well known from other novæ, especially N. Pic and N. Her) is also present, as well as a few other faint emissions.

A most valuable continuous series of spectroscopic observations was

obtained at Mount Wilson. Preliminary results are described in the *Annual Report*, 1935–36, p. 181, and, further, in *P.A.S.P.*, **48**, 325, 1936, in a note by W. S. Adams, R. F. Sanford and O. C. Wilson on the three above-mentioned radial velocity curves.

The first extensive monograph on the star, by N. T. Bobrovnikoff, appeared in *Perkins Obs. Contr.*, No. 6. It discusses fully the spectrum between 1936 June 20 and September 16. The structure of *Hα* is studied especially. The absorption components of this line proved to be symmetrically placed on either side of the normal position of the line; in addition two components much displaced to the violet were present. There were also many fine sharp absorption lines, but attempts to identify them failed. Several interstellar lines, notably the strong ones of *Na*I and *Ca*II, are studied by Bobrovnikoff in considerable detail.

The distance of the nova was derived by P. W. Merrill and O. C. Wilson (*P.A.S.P.*, **48**, 230, 1936), using intensity measures of the interstellar lines of *Na*, *Ca*II and of λ 5780. They obtained 800 parsecs, corresponding to an absolute magnitude at maximum of $-7^{m}.2$.

7. *Nova Aquilæ* 1936, *No.* 1.—This star (=618●1936) was found by N. Tamm at Kvistaberg in Sweden, on a plate taken on September 18. The new object was of 8th magnitude, and its position $19^{h}\ 14^{m}.0\ +1°36'$.

The observations of this nova revealed an interesting light history, which shows resemblance to that of N. Her 1936. Reports are given in *I.A.U. Circ.*, No. 616, etc.; *Harv. A.C.* 388, etc.; in *A.N.*, **260**, 383, 1936; *A.N.*, **260**, 437, 1936 (containing also the comparison sequence with chart after the photometric measures by M. Beyer); *A.N.*, **261**, 66, 86, 146, 1936; *J.B.A.A.*, **46**, 398, 1936; *L'Astronomie*, **50**, 478, 1936; *Cœlum*, **6**, 215 and 221, 1936. In *P.A.S.P.*, **48**, 321, 1936, numerous magnitudes are given by C. F. J. Overhage and F. Zwicky, covering the time from August 19 to September 23. S. Kanda publishes his observations in *Mem. Astr. Soc. of Japan*, **5**, 84, 1936.

C. Hoffmeister writes in *I.A.U. Circ.*, No. 621, that the star is invisible on plates taken between 1928 and 1934 of which the magnitude limit is $16^{m}.5$. Examining, together with O. Morgenroth, the later series of plates, the measures he gives in *I.A.U. Circ.*, No. 618, show that the brightening must have occurred between 1936 July 17·9 ($< 11^{m}.0$) and July 20·1 ($9^{m}.7$). In July and August the light was varying between $9^{m}.7$ and $8^{m}.0$; and in September according to G. B. Lacchini between $7^{m}.8$ and $7^{m}.3$. M. Beyer draws attention to the big fluctuations the nova experienced, having a range of up to two magnitudes. In his *Jahresber. Priv. Sternw. Hamburg*, 1936, p. 6, he lists a number of maxima (the star being between $7^{m}.0 - 7^{m}.7$ on August 1 and 25, September 11, October 1 and 31, November 20) and minima ($8^{m}.5 - 9^{m}.1$, on August 13, September 23, October 8, November 7).

The fluctuations became somewhat smaller, after the nova had passed its maximum $7^{m}.0$ on October 1, a big drop to $9^{m}.0$ followed on October 8. The fading continued till the end of the year, when $9^{m}.5$ was reached.

The spectrum also showed great similarity to that of N. Her 1934 as it appeared during 1935 March. B. Lindblad (*I.A.U. Circ.* 616, and private communication) found the hydrogen, etc., absorptions on September 19

much displaced towards the violet, and notes further an interstellar K-line, which is probably strong, and some helium absorptions. On September 21 he finds a velocity of −800 km./sec., while the emissions seem to be displaced towards the red. Whilst the star was approaching its secondary maximum on October 1, the continuous spectrum grew stronger, and the Balmer lines apparently faded. A spectrum obtained by Lindblad at Saltsjöbaden on October 7 (see also *I.A.U. Circ.* 624) showed the bright Balmer lines with a very strong *Hα*, the forbidden lines [*O*I] 5577, 6300, 6363, [*N*II] 5755, the D-lines, *O*I 6157 and other emissions of *Fe*II and *N*II.

The Lick observations began on September 21, according to a note by A. B. Wyse in *P.A.S.P.*, **48**, 305, 1936. Three different absorption spectra were present: a faint one of *α* Cygni-type, displaced by about −400 km./sec.; hydrogen, −900 km./sec.; hydrogen and other gases, −1100 km./sec. The strong absorptions of the third spectrum were assigned mainly to *N*II, *N*III, *O*II, *He*I, *C*II. Emission bands were measured due to *H* and to the strongest lines of *Fe*II, *He*I, *O*II, as well as λ 4634–40, *N*III. About September 27 strong *Ca*II-absorptions, *H* and *K*, appeared, which persisted until November.

Of special interest is the announcement of the Union Observatory at Johannesburg, that the star has been resolved as a visual double (*I.A.U. Circ.* 618). The discovery was made on September 25 by W. H. van den Bos and W. S. Finsen. According to the data given in *A.N.*, **261**, 119, 1936, the nova is composed of two components, $8^m.6$ and $8^m.9$; on 193·675 the position angle was 140° and the distance 0″·18.

8. *Nova Sagittarii* 1936.—The third nova of 1936 was, like the first, found in Japan. On October 4 it was discovered by Okabayasi at Kobe, its magnitude being $4^m.5$, its position $18^h\ 4^m.6$ and −34° 21′, and its designation 619·1936. Observations were obtained by J. Jackson and R. Watson on October 6 and 7, when the star had already faded to the 6th magnitude (*I.A.U. Circ.*, Nos. 622, 624, 625). Further observations are published in *A.N.*, **261**, suppl. to No. 6241, 1936, *I.A.U. Circ.* 627, in *Cælum*, **6**, 215, 1936, and by S. Kanda in *Mem. Astr. Soc. of Japan*, **5**, 85, 1936. W. Koslov found the nova only $7^m$ on October 12, and L. Jacchia $8^m.4$ on October 21. According to Jackson the star was certainly fainter than $12^m$ on plates taken in 1931 and 1932.

The spectrum of N. Sgr was obtained with the 100-inch telescope, and described by A. H. Joy, W. S. Adams, Th. Dunham in *P.A.S.P.*, **48**, 328, 1936. Between λ 4000 and λ 5000 complex structure of the very broad emissions of *Hδ*, *Hγ* and *Hβ* was noticed; *He*I λ 4472 and other fainter emissions were also present. Two absorption components appeared, showing very large displacements of −3590 km./sec. and −2130 km./sec., respectively. The emissions exhibited two maxima, the stronger one being on the violet side, and displaced by −1580 km./sec. On October 4 in the region of λ 4600 a trace of the nebular stage was found. The width of the bright bands was then about 60 A. On October 8 strong interstellar sodium lines were measured; their intensity was considerably greater than in N. Lac, and leads to a distance of the nova of the order of 2000 parsecs.

9. *Nova Aquilæ* 1936, No. 2.—It is remarkable that this nova (=668● 1936; $19^h\ 23^m{\cdot}5$, $+7°28'$) escaped attention for many weeks during which it was much brighter than at the time of discovery, since it was situated in the immediate neighbourhood of N. Aql 1936, No. 1, which was kept under careful observation by numerous astronomers every night.

Again it was N. Tamm at Kvistaberg who made the discovery. On a plate of October 7 the nova was found as a star of $7^m{\cdot}6$. Tamm communicated his observation on October 20 to the Stockholm Observatory, whereupon B. Lindblad secured the first spectra.

The light history of this star proves to be very interesting. The plates previously taken for the first nova in Aquilæ enabled a continuous light curve to be established, and fortunately several earlier plates helped to fix the date of actual outburst within very close limits. According to M. Beyer (*A.N.*, **261**, 56, 1936) a plate taken 1936 August 26 showed no star brighter than $12^m{\cdot}5$ in the place of the nova. A series of Harvard plates gives the star as $13^m$ on September 19·5, as $11^m{\cdot}5$ on September 20·5 and as $6^m{\cdot}6$ on September 22·5. On the other hand, inspection of the patrol plates taken at the Observatories Berlin-Babelsberg and Sonneberg proved that the star was fainter than $9^m{\cdot}8$ on September 21·9, but had reached $5^m{\cdot}9$ on September 23·9. From these observations, therefore, we can deduce that a steady light increase was followed on the morning of September 22 by the "outburst" represented by a brightening of $3^m{\cdot}2$ within 0·6 days.

Of later observations we may mention that of Satô in Tokyo, giving $5^m{\cdot}7$ photographic on September 25.5 (*I.A.U. Circ.* 633); Harvard gives $6^m{\cdot}4$ for September 25·6. K. Lundmark reports, in *I.A.U. Circ.* 628, observations of B. Svenonius: $5^m{\cdot}0$ on September 26·8, $5^m{\cdot}2$ on September 27·8. The later plates show the star fading, so that the maximum of $5^m{\cdot}0$ was reached on September 25. During October the star's light decreased from $7^m{\cdot}4$ to $8^m{\cdot}9$, and by the end of December the magnitude was only $10^m{\cdot}3$. A note by L. Jacchia in *I.A.U. Circ.*, No. 633, states that observations in the second half of 1936 December suggest fluctuations of about $4^h$ period, and $0^m{\cdot}6$ range.

Reference must be made to the published observations in *A.N.*, **261**, 15, 1936, and in supplements to *A.N.*, **261**, No. 6241, further to *A.N.*, **261**, 54, 1936, *A.N.*, **261**, 146 and 199, 1936. The last-mentioned account includes also a photometric comparison sequence measured by M. Beyer, as well as a chart of the field. Observations are also given in *Cælum*, **6**, 215, 1936, and in *L'Astronomie*, **50**, 543, 1936. S. Kanda gives his results in *Mem. Astr. Soc. of Japan*, **5**, 91, 1936.

According to *I.A.U. Circ.*, No. 625, and to a private communication, the spectrum closely resembled that of Nova Lacertæ 1936. The plates obtained by Lindblad at Stockholm show very strong Balmer lines with continuous emission beyond the limit in the ultra-violet. Strong bands appeared at λ 4650 and λ 5760; the latter experienced between October 20 and 22 a conspicuous change.

The Lick spectra (A. B. Wyse, *P.A.S.P.*, **48**, 306, 1936) of October 20 show the Balmer lines and H and K of *Ca*II displaced by −1000 km./sec.

A second set was displaced by −1900 km./sec., and included numerous *N*III-lines. The emission [*O*III] λ 5007 was also present, as well as the strong λ 4640-band, and lines of *He*I. McKellar reports (*Harv. A.C.*, No. 397) on October 22 an additional set of Balmer lines, displaced by −1200 km./sec. Wyse remarks that by the end of October the hydrogen absorptions had almost disappeared, and that in general the continuous spectrum had faded relatively to the emission lines.

10. *P Cygni.*—The studies by O. Struve and C. Beals of this most interesting star have been described already in *M.N.*, **96**, 365, 1936. The past year brought four new contributions to the problem.

A paper by E. Kharadse, V. Nikonov, and P. Kulikovsky, published in *Observatory*, **59**, 88, 1936, confirms the suspected variability of P Cygni by accurate photo-electric observations made at the Abastuman Astrophys. Observatory in Georgia, whereby the star was found to change through a range of $0^{m}.16$ within a month.

In *Pulk. Circ.*, **17**, 13, 1936, Gerasimovič presents a clear exposition of the great complications which render the disentanglement of this spectrum so difficult.

O. C. Wilson (*Ap. J.*, **84**, 296, 1936) examines numerous spectrograms taken at the Lick and Mount Wilson Observatory. He points out that the Balmer lines have each two absorption components, which vary in intensity, and probably in position. Sometimes one of the latter becomes invisible. No period for the variations could be deduced, but significant changes are found to occur within intervals of about one month, a fact which may perhaps connect with the photo-electric results just mentioned; a similar cycle is indicated for the helium lines.

E. K. Kharadse investigates in *Z. f. Aph.* eighteen plates taken at the Simeis Observatory, measuring the radial velocities of the absorptions and emissions between λ 3750–6680. He designed a model to represent the photographic effect of the emission components upon the displacements of absorption lines, and constructed a reduction curve to take this effect into account. The relation between reduced absorption velocities and ionisation potentials found by Struve has been strengthened; but there is no change with the intensities. An apparent correlation between displacement and wave-length is also explained away as a photographic effect.

11. *Super-Novæ.*—The fact is pointed out by F. Zwicky (*Proc. Nat. Acad.*, **22**, 459, 1936) that since super-novæ during several weeks radiate as much energy as a whole galaxy of stars, observation of these unique objects will furnish valuable information on fundamental problems, such as the generation of energy in stars, the evolution of stars and stellar systems, the origin and the characteristics of cosmic rays and the nature of atomic rays travelling in interstellar space.

Super-novæ have been investigated during the past year in numerous important papers. W. A. Johnson deals in *Harv. Bull.* 902 with the only known spectrum of Nova Centauri 1895 (Z Cen), which was observed in N.G.C. 5253. He succeeds in deriving wave-lengths from this objective prism plate, and finds that the spectrum consisted in bright lines, and is not of class R

as assumed hitherto, but (as C. Payne-Gaposchkin expresses it, in *Ap. J.*, **83**, 173, 1936) is that of a nova in the "4640 stage." But the bright lines appear about five times as broad as those usually observed in the spectra of novæ, and this suggests an expansion velocity of the order of 10,000 km./sec. Mrs. Payne-Gaposchkin states that this observation removes the last of the novæ which were supposed to show only absorption spectra after maximum. In *P.A.S.P.*, **48**, 194, 1936, F. Zwicky estimates the distance of Z Cen to be less than one million light years, on the basis of a "lifetime" of 80 days.

The spectrum of the super-nova S Andromedæ 1885 has also been analysed again. Discussing the contemporary reports, C. H. Payne-Gaposchkin (*Ap. J.*, **83**, 245, 1936) arrives at the conclusions that the spectrum contained bright lines, although these may have presented little contrast to the background, and that the spectra of super-novæ do not seem to distinguish themselves essentially from those of ordinary novæ.

E. Hubble and G. Moore report in *P.A.S.P.*, **48**, 108, 1936, the important discovery of a new super-nova in N.G.C. 4273. This appeared between 1936 January 2 and January 18, and is the fifth nova which is recorded in spirals of the Virgo cluster during the last 17 years. This success is the result of a careful and regular seven-year search of the cluster since 1928, undertaken by Hubble and Baade on Mount Wilson, and by Zwicky in Pasadena. The light-curve is one of the best obtained for a super-nova, the star being followed down to $19^{m}\cdot2$, which it reached on May 22. W. Baade concludes that the maximum must have been close to magnitude $14^{m}\cdot4$ (*P.A.S.P.*, **48**, 226, 1936). Using this value, and Hubble's recently derived distance modulus of the cluster, he obtains the absolute magnitude $-12\cdot4$.

Most fortunately M. L. Humason succeeded in obtaining early spectra of this super-nova in 1936 February (*P.A.S.P.*, **48**, 110, 1936). This was made possible by applying the new nebular spectrograph with a dispersion of 500 A./mm. The interpretation of this spectrum is not easy, the half-widths of $H\beta$ and $H\gamma$, *e.g.*, being 93 A. On April 21–23, when the nova was $17^{m}\cdot4$, successful spectra were also obtained, the exposure time being 17·5 hours. According to *P.A.S.P.*, **48**, 228, 1936, an unique spectrum resulted, consisting only of a single wide band of great intensity, whereas all other features of the earlier spectra had faded away. This band, centred at $\lambda$ 4640, may be due to *N* III, etc., as in common novæ. It has a width of 203 angstrom, corresponding to a velocity of expansion of the emitting gas shell of 6600 km./sec.! This result confirms the predictions of Baade and Zwicky that the gaseous shells in super-novæ are expelled at extraordinary speeds.

A bright nova in the spiral nebula N.G.C. 5236, the discovery of which was announced in 1923 by C. O. Lampland (*Harv. Bull.*, No. 786, *P.A.S.P.*, **35**, 166, and *Pop. Astr.*, **31**, 648) is discussed anew by the same author in *P.A.S.P.*, **48**, 321, 1936. An absolute magnitude of $-12^{m}$ is given, and it is suggested that this object might be placed among the super-novæ.

The physical conditions in super-novæ are dealt with by C. H. Payne-Gaposchkin in *Proc. Nat. Acad.*, **22**, 332, 1936. It is pointed out that the

maximum dimensions of these stars are larger than those of galactic novæ in rough proportion to the radial velocities, as deduced from the widths of the bright lines. The outburst of a supernova is thus regarded as a phenomenon that differs only in scale from that of a normal galactic nova.

The interesting work initiated by Baade and Zwicky on the structure of super-novæ and its relation to the cosmic rays, etc., is continued by two papers by Zwicky in *Proc. Nat. Acad.*, **22**, 457 and 557, 1936, and in one article in *P.A.S.P.*, **48**, 191, 1936. Investigating theoretically the physical properties of some simple models of a nova outburst, he obtains three relations between the four observable features of novæ, on which he concentrates his attention: absolute visual magnitude at maximum, total energy emitted as visible light, the velocity of expansion and the lifetime. The resulting expansion-luminosity-relation, the life-luminosity-relation, etc., are discussed, as well as the characteristic temperatures. Here Zwicky visualises two critical surfaces in a super-nova: the first, the "boundary surface," is defined by the outermost layers ejected from the nucleus; the second, the "surface of separation," is the demarcation between the matter which is ejected into interstellar space, and that which remains with the central star; at this surface the order of temperature is estimated in different ways.

The great importance of these novæ for distance determination is emphasised by Zwicky. He points out that such a determination can be carried out from the nearest stellar distance to the limits of the visible universe without any gap. Super-novæ are the only individual stars which can be seen at all distances in which extragalactic nebulæ can be reached. Their observation, therefore, promises to furnish invaluable information on every kind of cosmological problem.

In conclusion mention should be made of some shorter papers on this subject. A general account by E. de la Meillaie appeared in *L'Astronomie*, **50**, 41, 1936. H. Zanstra discussed in *Naturwissenschaften*, **23**, 867, 1935, the rôle of the super-novæ as a possible course of cosmic rays. In this connection also an article in *Nature*, **138**, 344, 1936, is of interest, in which J. Barnóthy and M. Forró state that Nova Lacertæ 1936, during the first month after discovery, caused no increase in cosmic ray activity.

A. B.

## *Double Stars*

*New Pairs.*—Another nova (618·1936 Aquila) has been found to be double by Finsen (*A.N.*, **261**, 119).

*Memoirs R.A.S.*, **65**, part 3, contains a large number of new southern pairs discovered with the 27-inch refractor of the Lamont-Hussey Observatory at Bloemfontein; Rossiter numbers 2233–3340, Donner 1–1057 and Jessup 1–854. Milburn gives his new pairs 970–997; 24-inch reflector (*M.N.*, **96**, 266). Olivier publishes 16 new pairs (149–164) and some corrections to his earlier discoveries (*A.N.*, **258**, 409).

Barton continues his publication of double stars from astrographic catalogues—Perth, Tacubaya and Helsingfors (*A.J.*, **45**, 33 and 99).

Stearns, on photographic plates, discovered the duplicity of Furuhjelm's companion Capella H (*A.J.*, **45**, 120); this has been confirmed visually by Kuiper, who also gives notes on some visual binaries of large parallax (*Ap. J.*, **84**, 359).

*Measures.—J.d.O.*, **19**, 63, 85, 98 and 119, gives measures by Baize with the 12-inch refractor at Paris.

*Poulkovo Obs. Circ.* 15 gives measures made by Renz with the 15- and 30-inch refractors in the years 1894–1897; measures by Vyssotsky with the 15-inch in 1913–1915 are given in *A.N.*, **258**, 401. Greenwich Astronomical Results, 1934, B2, gives further measures with the 28-inch refractor.

Milburn's 27th series is given in *M.N.*, **96**, 266, 24-inch reflector.

Aller continues his measures in *A.N.*, **259**, 133.

Measures on 70 Ophiuchi by Szkalnitzky are given in *A.N.*, **258**, 379. A note on the increasing distance of the components of Nova Herculis is given by Van Biesbroeck (*P.A.*, **44**, 211).

Photographic measures on parallax plates taken with the 26-inch Yale-Johannesburg refractor are given by Alden (*A.J.*, **45**, 73).

Ferwerda (*B.A.N.*, **7**, 308) has a short series of measures from plates taken with the Leiden 13-inch.

Bemporad (*Contr. Astrofis. Catania*, 21) gives measures of double stars on astrographic plates.

Ross gives photographic measures of the close pair ADS 13277, distance 0″·76, with the Lick 36-inch (*P.A.S.P.*, **48**, 221).

Wilson has used a simple interferometer of the type described earlier by Finsen (*Union Obs. Circ.* 90) on the Flower 18-inch refractor. His results are published in *Journal of the Franklin Institute*, vol. **221**, No. 1, but a more accessible summary is given in *P.A.S.P.*, **48**, 195.

*Orbits :—*

| ADS | Computer | *P* | *a* | *e* | Reference |
|---|---|---|---|---|---|
| | | | ″ | | |
| 2959 | Finsen | ∞ | ... | 1·0 | *U.O.C.* 95. |
| 9301 | Quilliam | 29·40 | 0·21 | 0·14 | *P.A.S.P.*, **48**, 283. |
| 9578 | Voronov | 165·0 | 1·020 | 0·58 | *Tashkent Bull.* 6. |
| 10087 | Camp | 132·9 | 0·97 | 0·59 | *A.J.*, **45**, 24. |
| 10345 | Komendantoff I | 0436 | 11·818 | 0·802 | *Poulkovo Obs. Circ.* 16. |
| | ,, II | 1386 | 5·50 | 0·576 | ,, ,, ,, |
| 10585 | Aitken | 76·0 | 0·64 | 0·28 | *P.A.S.P.*, **48**, 175. |
| 11077 | Luyten, Ebbighausen | 54·7 | 1·13 | 0·80 | *A.J.*, **45**, 54. |
| 15270 | Komendantoff | 514 | 4·556 | 0·430 | *A.N.*, **260**, 15. |
| 16800 | Arend | 49·4 | 0·20 | 0·43 | *A.J.*, **45**, 71. |
| 8094 | ,, | linear formula | | | *A.J.*, **45**, 63. |
| *h* 3683 | Finsen | ∞ | ... | 1·0 | *U.O.C.* 95. |
| −8°·4352 | Kuiper | 1·655 | 0·185 | 0·0 | *P.A.S.P.*, **48**, 19. |
| Brs O 13 | Russell | 242 | 4·94 | 0·544 | *A.J.*, **45**, 95. |
| | Finsen | ∞ | ... | 1·0 | *U.O.C.* 95. |
| $\phi$ 283 | ,, | 6·75 | 0·214 | 0·62 | ,, ,, |

Alden discusses the apparent orbits of $\beta$ Cap and $\chi$ Dra (*A.J.*, **45**, 82 and 113), Reuyl the variable proper motion of Ross 614 (*A.J.*, **45**, 133) and Hertzsprung the geometric elements of $\alpha$ Cen (*B.A.N.*, **7**, 329).

*Miscellaneous.*—Photographic determinations of mass ratio from parallax plates are given for $\tau$ Cyg by van de Kamp (*A.J.*, **45**, 121), for Sirius by van de Kamp and Barcus (*A.J.*, **45**, 124) and for $\epsilon$ Hya by Pitman (*P. Am. Ast. Soc.*, **8**, 221).

Pitman gives photographic measures of artificial double stars (*P. Am. A.S.*, **8**, 220), and Labitzke investigated the systematic errors in photographic observations of double stars (*A.N.*, **258**, 225).

Danjon determined the magnitude and colour of Sirius B (*J.d.O.*, **19**, 200). Worssell gives a list of stars which have shown abnormal occultations by the Moon (*U.O.C.* 95). Many of these are known visual doubles, and some have since then been found to be double, so that the stars on this list may repay visual investigation with a large refractor.

Salet (*J.d.O.*, **19**, 14) writes on the method of the reversing prism.

Rakowiecki (*P. Astr. Obs. Warsaw Univ.*, vol. 9) gives a new method for determining the orbit of a double star. This is apparently the method of Kowalski adapted to Thiele's polar elements (not the Thiele-Innes elements; see *U.O.C.* 86). It has the same drawbacks as Kowalski. Finsen gives the notation, formulæ and tables required for the computation of parabolic orbits (*U.O.C.* 95), and van den Bos, in the same publication, some remarks on Thiele's method.

Two further attempts at explaining the apparent relation between period and eccentricity are made by von Schelling (*A.N.*, **258**, 369) and Horrocks (*M.N.*, **96**, 534); Finsen, on the contrary, shows that this relation cannot be accepted as established by the observational data (*M.N.*, **96**, 862).

W. H. v. d. B.

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## ADDRESS

*Delivered by the President, Mr. J. H. Reynolds, on the award of the Gold Medal to Dr. Harold Jeffreys*

The Gold Medal of the Society has been awarded this year to Dr. Harold Jeffreys for his researches into the physics of the Earth and other planets, and for his contributions to the study of the origin and age of the Solar System.

Since he was elected a Fellow in 1915 he has contributed no less than fifty-seven papers to the *Monthly Notices* and the *Geophysical Supplement*, besides many papers communicated to the Royal Society, the *Gerlands Beiträge für Geophysik* and other scientific journals.

The subjects he has dealt with are truly catholic in their scope, and include cosmogony and stellar and nebular astronomy as well as problems connected with the Solar System, such as planetary perturbations. But his papers on these branches of mathematical astronomy, valuable as they are, are more or less incidental to his investigations on the constitution of the Earth and physical questions connected therewith, which he has put before us as a consistent whole in two books, *The Earth*, published in 1924, with a second edition in 1929, and his more recent work *Earthquakes and Mountains*. The first of these is an elaboration and extension of his previous papers, and comprises the work for which he was awarded the Adams Prize in 1927. *Earthquakes and Mountains* is a book in which the problems of terrestrial physics are set forth in a simpler form, without the elaborate mathematics of his earlier work, and it therefore appeals to a wider scientific public.

When Jeffreys first began to interest himself in geophysics the science was in its infancy, and the work which had been done was somewhat sporadic and disconnected. On the observational side Milne and others had designed seismographs for registering earthquake tremors, and records were being made in many countries. A Seismological Committee of the British Association had been appointed in 1896, of which Turner ultimately became Chairman and J. J. Shaw Secretary.

My old mathematical master, Charles Davison, was also another well-known early worker in seismology.

After Milne's death, his seismograph was removed from the Isle of Wight to the Oxford University Observatory, and under Turner's supervision this Observatory became a sort of clearing-house for earthquakes, where the co-ordination of seismic records from all over the world was undertaken. Then important work on the gravity constant and its anomalies in various regions of the Earth had been accomplished, especially in India and the United States.

On the theoretical side the figure and constitution of the Earth and the

history of the Earth-Moon system were the subjects of mathematical investigation by George Darwin and Poincaré, and many physicists and geologists had made contributions to the problems involved in the interior constitution of the Earth.

But it was left to our Medallist to take all these various researches and combine them, together with data derived from other sources entirely. He found it was not enough to be only a mathematical physicist of the first rank. He had to be an engineer, a geologist, and a mineralogist as well. Such problems as the strength and rigidity of materials, stresses, crushing and breaking strains, fusing points of metals and minerals, the composition of sedimentary and igneous rocks and their crystalline structure, all came within his purview.

The behaviour of materials such as granite and basalt can be tested in the laboratory to a pressure of 30,000 atmospheres or, as engineers would say, about 200 tons to the square inch. This corresponds to a depth of 120 km. in the Earth's crust, but what are the conditions of matter at pressures of 10,000 tons to the square inch, or thereabouts, which presumably must obtain near the centre of the Earth? Then, with regard to temperature, we know that near the surface of the Earth in Europe this increases generally with depth by about 30° C. per km. The rate of increase differs considerably from one point of the Earth's surface to another. In North America it is three-quarters of this amount, and in South Africa only about one-half. In regions where volcanic activity has taken place in recent geological times the rates of increase are abnormally high. In a boring almost a kilometre deep at Buda-Pesth a temperature of 69° C. was reached at the bottom. In Tuscany and other places in Italy a similar rate of increase has been found. If we take an average and extrapolate from this, we find that at a depth of something like 50 km. we reach a temperature of 1400° C.—enough to fuse all but the most refractory substances.

But is it safe to extrapolate, and would not the increase in pressure alter the fusing point and also the rigidity? This undoubtedly takes place, for earthquake foci as deep down as 400 to 500 km. have been inferred from the various types of seismic waves and their times of travel to different stations. An earthquake focus at such a depth presupposes that the material there is strong enough to fracture, so we must assume that notwithstanding the probability of a temperature certainly equalling and possibly much exceeding the free fusing point, the material, whatever it is, has still considerable strength.

Then we have the complication introduced by radio-activity. A certain proportion of the Earth's internal heat, at any rate in the outer crust, is due to the presence in igneous rocks of radio-active metals such as uranium and potassium. What proportion of the Earth's internal heat is due to this cause, and how much to primeval heat still remaining from the time when the whole Earth was a molten globe?

The deductions which geophysicists can make as to the internal structure and composition of the Earth below such an insignificant fraction of the Earth's radius as a few kilometres must therefore be in the nature of extra-

polations, and the validity of the conclusions reached depends entirely on the assumptions made as to the behaviour of various substances under conditions of heat and pressure which are, for the most part, far beyond the limit of verification in the laboratory.

But, notwithstanding these formidable difficulties, Jeffreys has boldly grappled with the many problems involved, and has presented us with a conception of the Earth's interior which fits in remarkably well with the known data. He first of all postulates a shell which behaves mechanically as a solid, reaching down as far perhaps as 3000 km. This shell is of a density which increases from the surface downwards, the surface density being about 2·7 and the lowest layer about 5. It is worth noting at this point that Jeffreys' work is quite inconsistent with Wegener's hypothesis of the continents floating on a viscous magma comparatively near the surface, and it is equally opposed to the tetrahedral theory of the formation of the continents. There is a discontinuity between the central core and the shell in the way of transmitting earthquake waves, and as the core is apparently incapable of transmitting distortional waves at all, it is concluded that the central core is still in a molten condition.

Its density is only consistent with the heavier metals. Iron is the most common metal of high specific gravity found at the surface, so the assumption is made that the core is probably of this metal, the specific gravity under these central conditions of pressure being found to be 12, as compared with 7·5 at ordinary atmospheric pressure.

I suppose that Jeffreys would admit the possibility of other heavy metals, such as nickel and manganese, being present in the Earth's interior besides iron, as these also would sink towards the centre when the Earth was in a molten condition. The distribution of metals in the Earth's outer crust does not necessarily imply that these metals remain in the same proportion downwards towards the centre, and the erupted igneous basalts containing iron seem to have their origin at the depth of only about 30 km. I mention this because in 1870 masses of a native alloy of nickel, iron and cobalt were discovered off the west coast of Greenland. At first it was thought that they were meteoric in origin, as nickel-iron is a common constituent of meteorites. But it was later pointed out by Steenstrup that the nickel-iron was associated with ultrabasic igneous rocks such as peridotite and olivine, and that these rocks contained an unusually large proportion of iron. Judd suggested that the nickel-iron had been extruded with the ultrabasic rocks from a very deep horizon of the Earth's crust, and therefore gave an indication of the materials at depths not usually drawn upon in volcanic eruptions.

From a detailed study of the times and rates of travel of the two main types of earthquake waves, the primary and the secondary, with their associated surface waves, Jeffreys assumed that the principal constituent of the Earth's solid shell is olivine, as this mineral is about of the right density required. But this does not extend to the surface, where there is a layer of granite under the accumulated sedimentary rocks of the continents, and a layer of denser rocks, presumably basic, lies under the oceans. The

granitic or continental layer is estimated to be about 10 km. thick, and two other layers of about the same thickness but discontinuous in their density, may lie between it and the lower shell of olivine or its equivalent.

Stoneley has also made an estimate of two discontinuous surface layers, and he finds a thickness of 12 km. for the granitic layer and 24 km. for the intermediate layer. There seems to be another discontinuity of density at something like 400 km. down.

A particularly interesting feature of Jeffreys' work on the internal constitution of the Earth is that dealing with temperatures, and the part played by radio-activity in the Earth's history and its present effects. In substances that contract on solidifying the fusing point is raised by pressure, so that at great depths materials must be still solid at temperatures much higher than the fusing points at the surface. This rise in the temperature of melting points due to pressure is about 3° per kilometre near the surface, at greater depths probably somewhat less than this. While the Earth was molten the temperature would increase downwards, but the fusing point would increase faster, and as the whole cooled at a uniform rate, so solidification must have taken place from the bottom upwards. If the core is of metals, which have a lower fusion temperature than the basic silicates of which the outer shell probably consists, then the core would remain liquid, while the outer shell, still liquid at the surface, would be solid at great depths. The core, therefore, got trapped under a layer of badly conducting silicates, and its temperature has not dropped greatly since it was originally formed. On this hypothesis the whole process of solidification did not take more than some tens of thousands of years.

It is now established, I think, that the Earth's surface temperature is practically controlled by solar radiation alone, and it has been so during the greater part of geological time. The average supply of heat from the Sun over the surface is 0·007 calorie per square centimetre per second. The rate of conduction from the interior is of the order of $2{\cdot}6 \times 10^{-6}$ calorie per square centimetre per second—a negligible amount in comparison. If we find evidence of variation in surface temperatures in past geological epochs, we must attribute the variation either to changes in the Sun's radiation or to altered meteorological conditions. I find it difficult to imagine altered general meteorological conditions without a corresponding cause in solar radiation.

But the small amount of heat still leaving the Earth by conduction from the interior is partly a relic of the primeval heat from great depths, and partly heat generated more recently by radio-activity. The radio-active metals, uranium, thorium and potassium, are found in all surface rocks in minute but measurable amounts.

Granite contains a greater proportion of these radio-active metals than the basic rocks. In average granite the rate of generation of heat is found to be $1{\cdot}3 \times 10^{-12}$ calorie per cubic centimetre per second, while for basalt it is only $0{\cdot}50 \times 10^{-12}$ calorie. Small as these amounts are, it is found that the total heat now being lost from the Earth by conduction can be supplied by a layer of granite 20 km. thick over the whole surface. This leaves nothing to be supplied from greater depths, and fixes an upper limit for the

thickness of the granite layer. But it has been inferred from the study of near earthquakes and surface waves that the granitic layer is only 10 km. ± 3 thick. There must be, therefore, as large a proportion of radio-active elements in the upper 10 km. as in all the rest of the solid shell beneath it. This leads to the conclusion that radio-activity decreases rapidly with depth, and further, that the radio-active metals became concentrated in the surface rocks in the early history of the Earth. It is very difficult to explain how such a concentration can have occurred, as uranium and thorium are right at the end of the atomic scale and would be expected to gravitate towards the centre during the Earth's formation. There may be a chemical explanation in the formation of crystals, as the radio-active metals are found to occupy the interstices between the crystals of the minerals forming granite. There seems, indeed, to be a divergence of view amongst geologists and geophysicists on this question of radio-activity and Jeffreys' standpoint has not escaped criticism, but he puts forward a strong case for his conclusions. In any case, volcanoes and subterranean igneous phenomena such as intruded masses of granite and basalt must have some source of heat not a great distance down to explain them, and radio-activity in the Earth's crust does this. The presence of water in connection with volcanic eruptions is well known, in fact without water it is doubtful whether eruptions would take place at all. It was at one time supposed that the water from great depths of sea such as are usually associated with volcanoes percolates through faults and fissures in the crust to the potentially liquid magma below, and the expansive force of steam forces the magma to the surface and so forms a volcanic region. It is a remarkable fact that the presence of water lowers the melting point of rocks considerably. American geologists have found that the basalt in the crater of Kileuea is still liquid at a temperature of 600° C. When it solidifies its water content is expelled into the atmosphere, and to melt it again a temperature of 1200° C. is necessary. Jeffreys' view of the cause of volcanic phenomena is somewhat different from the old geological theory. He thinks with Judd and others that the water is already contained in the potentially liquid and heated rocks forming the crust, and it is not necessary to bring in percolation. He places the origin of volcanic lavas at the base of the intermediate layer, about 30 km. down. At this depth the temperature would be almost sufficient to melt basalt with its actual water content. Any alterations of conditions tending to raise the temperature locally will, therefore, take the surrounding rock above the critical temperature and fusion will take place. As fusion increases the volume, this may be enough to burst its way upwards. When the magma fails to reach the surface, but intrudes itself between the upper strata, we have what geologists call a bathylith, a laccolith or a sill, according to its form. Such intrusions of basalt and granite are well known in various parts of the world and are sometimes of enormous extent. In British Columbia there is a bathylith which can be traced for over a thousand miles, and the Whin Sill underlies most of Northumberland and Durham. If the magma reaches the surface, then we have true volcanic activity.

There still remains the question of the originating cause of the pressure,

which obviously is required to force the liquid magma either to or near the surface. Rocks expand in melting by about 10 per cent., and as basalt is 10 per cent. heavier than granite, fused basalt and solid granite are of about the same density. Perhaps conduction from the local mass of high temperature fused rock below has the effect of melting the rock above it. If so, the first lavas to find their way to the surface in a new outbreak should be acid, followed by an intermediate type such as trachyte and ultimately basalts. Geologists have found evidence for this in various continental regions of the Earth.

Then the water held in basalt at high pressures is considerable, and the expansive force of steam and other active gases are plainly evident in volcanic eruptions. But we are still without any very definite information of the causes which underlie volcanic phenomena. There is no doubt that they are connected with mountain-ranges of the folded type, for it is in these regions that active and extinct volcanoes are found to-day all along the western coasts of America and from Japan to New Zealand in the Pacific, and in parts of the Eurasian continent. There is some connection between volcanoes and earthquakes, although the connection is indirect, for great volcanic eruptions are not necessarily associated with the great earthquakes, which may occur in regions where there are no volcanoes at all. On the other hand, volcanic eruptions are often attended by local earthquakes, but these can be put down to alterations in the surface loads owing to redistribution of material above and below ground.

Jeffreys is of the opinion that most of the water in the ocean was originally held in solution in the liquid magma, and was driven out of the surface by cooling and crystallization. He even suggests that the two principal constituents of the atmosphere, oxygen and nitrogen, were expelled from the crust in the same way, the oxygen in the form of carbon dioxide and nitrogen as ammonia ($NH^3$).

I will now pass on from these questions of the Earth's internal constitution to Jeffreys' work on the figure of the Earth. The ellipticity of the Earth was first determined trigonometrically by measuring the length of a degree on land northwards towards the pole. The value found by Clarke in this way gave 1/294·9 in 1866. Hayford in 1909, from a trigonometric survey of the U.S.A., found it to be 1/297. In this value isostasy was included for the first time in reducing the observations.

Laplace as long ago as 1799 used the constant of gravity for determining the ellipticity. This method has been much developed in recent years, and it has been found that in certain regions of the Earth there are considerable abnormalities from the standard.

In the East Indies, Meinesz, who used a Dutch submarine for his observatory, found long strips where gravity is abnormally small. In India, Graaf Hunter found a defect of 200 milligals in the Ganges basin changing to an excess of 100 milligals near Nagpur. But in general there is a variation of gravity at sea-level with latitude, and this has been utilised to determine the ellipticity fraction. In this way Bowie of the U.S. Geodetic Survey got a value of 1/297·4 and Heiskanen of the Finnish

Geodetic Institute a value of $1/296{\cdot}7 \pm {\cdot}6$. Then there is a systematic variation in gravity with longitude, which Heiskanen explains as an ellipticity of the Equator, the difference between the major and minor axes of the geoid being 690 metres.

But there is a third method of determining the ellipticity of the Earth, from the precession of the equinoxes. The constant of precession $(C - A)/C$, where $A$ and $C$ are the moments of inertia about the equatorial and polar radii respectively is known to a high degree of accuracy.

Newton was the first to demonstrate the ellipticity of the Earth entirely on theoretical grounds, as he found that to explain precession a spherical Earth was not possible. He showed that precession was due to gravity effects of the Sun and Moon on the equatorial bulge. Sir George Darwin calculated the ellipticity on certain assumptions as to the distribution and viscosity of matter in the interior of the Earth and found a theoretical value of $1/296{\cdot}4$. Neither the distribution or fluidity he adopted would be accepted to-day, but, according to a theory of Radau, the distribution of density with distance from the centre makes very little difference to the results. Any distribution which makes the precessional constant right will make the degree of ellipticity the same, and also the mean moment of inertia. As Jeffreys points out, the amount of variation given by the theory of the fluid Earth only varies by 6 milligals from the actual figure of 5000 milligals by which gravity increases from the Equator to the pole. He has recalculated the ellipticity from the precessional constant, taking into account recent knowledge of the interior of the Earth, and arrives at a value of $1/297{\cdot}9$. He also proves that the ellipticity of the strata of equal density increases steadily from the centre to the surface.

Then Jeffreys has dealt with the question of the tidal theory which G. H. Darwin had developed in his monumental work on the subject. Darwin took the friction necessary to explain the apparent acceleration of the Sun's and Moon's longitude to be due to internal viscosity only. But recent work by G. I. Taylor and others have shown that friction of the oceanic tides in narrow seas is sufficient to account for the greater part of the inferred slowing rotation of the Earth, and, although internal friction must be taken into account, only about one-fifth of the whole is attributable to this cause. Jeffreys thinks that the resonance theory of the origin of the Moon from the Earth's tide when it was in a liquid condition and in rapid rotation cannot be accepted in face of present-day knowledge. The friction at the boundary of the core and the base of the solidifying shell would be so great as to dissipate the energy rapidly. The amplitude of the tide would never reach more than $1/20$ of the radius, a quantity far too small to produce instability, and it seems that the detached mass, even if we presume there was one, would have a velocity so small that it would at once fall back into the primary.

Reasoning from the state of our present knowledge as to the interior constitution of the Earth, Jeffreys deals with the probable constitution of the Moon. We should expect it to be composed of much the same materials as the Earth, although the proportions need not necessarily be the same.

Its average density is 3·33, and astronomical data make it difficult to suppose that it has any considerable central condensation, as De Sitter has shown. Its smaller size and a gravitational effect only one-fifth of what it is on the Earth would produce but little compression, and the value of 3·3 is in accordance with that found for the intermediate layer of the Earth's crust, after allowing for terrestrial compression. He therefore suggests that its mineralogical composition as a whole is similar to olivine. By analogy with the Earth's crust, the Moon must have contained as large or larger proportion of radio-active minerals in relation to its size as the Earth, and it is perhaps owing to this cause that the Moon's surface is so full of evidence of long-continued igneous and volcanic activity. No doubt chemical reactions also come into this question of internal and surface heat, both in the Earth and Moon. That large blocks of the crust were submerged by the once liquid maria in the intermediate stages of the Moon's early history is an obvious deduction from its present condition, and this epoch was followed by a gradual diminution of volcanic and plutonic energy. But, even at this later stage of the Moon's activity, such conspicuous craters as Copernicus and Aristillus were formed and remain to-day as typical examples of the lunar crater formation.

One notable feature of the distribution of the maria on the Moon's surface is that the great circle which roughly intersects them over the 3/5 of the surface accessible to us by libration is inclined to the Moon's equator by a considerable amount. It is difficult to locate such a great circle with precision, but its inclination to the Moon's equator is somewhere about 30°. It has been suggested that this great circle was coincident with the Moon's equator when the maria were formed. I have never seen this point dealt with theoretically, but it is of considerable importance.

Jeffreys has also investigated the inequality in the figure of the Moon first inferred by Laplace from the differences between the greatest and least moments of inertia, the greatest being about its axis of rotation, and the least about an axis pointing to the Earth. It is found that this difference is 16 times what it would be if the density were homogeneous and if the outer surface were spherical. He concludes that the frozen tide indicated by the protuberance took place when the Moon's distance from the Earth was 2/5 of its present distance and its period of revolution was about 6·3 of our present days. The matter within the Moon must now depart appreciably from the hydrostatic state, and must have maintained this departure for a large fraction of the Moon's age. The Moon's interior, therefore, has a strength comparable with that inferred for the Earth's solid shell.

And now we come to a part of Jeffreys' work which is of special interest to those of us who are observers of surface phenomena on Jupiter and Saturn. In a paper on "The Constitution of the Four Outer Planets," appearing in 1923 in the *Monthly Notices*, arguments were brought forward for thinking that these planets have solid rocky cores, surrounded by a layer of ice and with a deep atmosphere. Taking the age of Jupiter as equal to that of the Earth, $1{\cdot}6 \times 10^9$ years, and a surface temperature of 300° A., he shows by a simple equation that the planet must have lost $1{\cdot}5 \times 10^5$ calories

per gram of its mass. This would be sufficient to solidify it entirely on any reasonable estimate of its original temperature. The solid crust would slow down the rate of conduction from the interior as in the case of the Earth, and the proportion of heat radiated from the planet would be only a negligible fraction of that received from the Sun. In a further paper in 1924 he develops this idea by applying the Radau Darwin theory of the figure of the Earth to determine the moments of inertia of Jupiter and Saturn from their ellipticities. He infers from the moments of inertia that Jupiter and Saturn must be much more condensed towards the centre than the Earth. This result had indeed been already found by Darwin on the assumption that Laplace's law of density holds in these planets. If we take the mean density of Jupiter as 1·36 and of Saturn as 0·63, then for Jupiter the surface density must be less than 0·9 and for Saturn less than ·31. These limits, he says, have been computed on an extreme hypothesis; the actual surface densities must be much less and the densities throughout considerable fractions of the volume must be smaller than these limits. He puts Jupiter's atmosphere as probably 9 per cent. and Saturn 23 per cent. of the planet's radius, and discusses the possible constituents of their atmospheres, all of them in the first 8 numbers of the atomic scale, with their molecular combinations. Two of the gases in his list, ammonia and methane, have actually been identified in Jupiter's and Saturn's spectra by Wildt since Jeffreys' paper was published. He suggests that the clouds forming the visible surface consist of solid particles of ice or carbon dioxide. Such a supposition implies that the atmosphere is of sufficient density to support these particles. Actual bolometric measures of the radiation from the visible surface of the Jovian atmosphere by Menzel in 1924 showed a temperature of 150° A., and this, although low, differs considerably from Jeffreys' estimate based on the solar radiation alone of 110° A. He suggests that the difference may be due to the presence of radio-active substances in the solid core of the planet giving an internal source of heat. It is perhaps a matter of argument whether elements of such high specific gravity are probable in the four outer planets in sufficient proportion to increase the surface temperature appreciably. In any case, Jeffreys has given good reasons for rejecting the old view that Jupiter and Saturn were planets with heated and probably molten surfaces surrounded by a dense atmosphere of vapour. But it is doubtful even now whether his views are entirely acceptable to observers of Jupiter, either visual or photographic. Their principal difficulty lies in the observational evidence, which is conclusive as to the great turbulence of the Jovian atmosphere. There is strong evidence of vigorous convection currents, which can only be explained by a considerable temperature gradient. Such a gradient is, no doubt, in the lower ranges of temperature, as Jeffreys has shown, but it is difficult to explain by solar radiation alone. It is hardly probable that the deep and cloud-laden atmosphere of Jupiter could transmit the longer wave-lengths sufficiently to heat a rocky or watery surface as on the Earth, and a surface heated very considerably above 150° A. seems necessary to account for the observed rapid local changes in the Jovian atmospheric circulation.

Then there are the questions involved by the known presence of methane and ammonia. How do the physical properties of these gases under probable atmospheric pressures fit in with the idea of very low temperatures at a great depth? These are perhaps points which our Medallist will take into consideration in further investigations on this interesting but difficult subject. At present he prefers to keep an open mind on the question.

It may be that a detailed study of ultra-violet and infra-red photographs of Jupiter will throw some light on the distribution and speeds of convection currents and the origin of the cyclonic forms which often appear in the belts.

The increase in the intensity of the molecular bands of methane in Uranus and Neptune have been taken simply as a result of the decreasing heat arriving from the Sun. The low critical temperature of methane certainly supports this view. It is interesting to compare the mean densities of the four outer planets. Russell, Stewart and Dugan give that of Jupiter as 1·34, Saturn 0·71, Uranus 1·27 and Neptune 1·58. As Jeffreys points out, we have not the same information with regard to Uranus and Neptune that we have for Jupiter and Saturn as to the rotation periods and ellipticities, so we cannot derive their moments of inertia, but there is no reason to think that their general constitution is much different, and we must conclude that the materials of which the globes of these planets are composed are very much lighter than those of the Earth, and that they are in a solid form at very low temperatures.

Jeffreys' work has been so voluminous that I have only been able to deal with a small fraction of it in this Address, but I hope I have said enough to indicate its originality and its comprehensiveness. In work like this, which has so many points of contact with other branches of science, it is of course possible that modification of his ideas may have to be made in the light of fresh researches. But that is the way all scientific knowledge grows. It is quite certain that no new scientific idea has ever been put forward complete and proved in every detail. It is only by a gradual building up of knowledge and by discarding hypotheses which have not stood the test of time that we can progress, and even the discarded hypotheses have had their uses in a negative, if not in a positive, sense. We all hope that Jeffreys' future work will be as fruitful and important as his past work.

Dr. Jeffreys, on behalf of the Royal Astronomical Society, I have much pleasure in handing you the Gold Medal, and may you long continue your researches in the subjects you have chosen.

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